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BULLETIN OF THE IMPERIAL INSTITUTE

Periods

A QUARTERLY RECORD OF PROGRESS IN TROPICAL AGRICULTURE AND INDUSTRIES AND THE COMMERCIAL UTILISATION OF THE NATURAL RESOURCES OF THE COLONIES AND INDIA

EDITED BY THE DIRECTOR AND PREPARED BY THE SCIENTIFIC AND TECHNICAL STAFF OF THE IMPERIAL INSTITUTE AND BY OTHER CONTRIBUTORS

HONI SOIT QUI MAL Y PENSE

VOL. XIII. 1915

LONDON
JOHN MURRAY, ALBEMARLE STREET, W.

ERRATA TO VOL. XIII

p. 77, line 11 from bottom, *for* Bulletin 190 *read* Bulletin 160.
p. 184, line 4 from bottom, *for* 1913 *read* 1915.

BULLETIN OF THE IMPERIAL INSTITUTE

VOL. XIII. 1915

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THE IMPERIAL INSTITUTE

OF THE

UNITED KINGDOM, THE COLONIES, AND INDIA

THE Imperial Institute was erected at South Kensington as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire by arranging comprehensive exhibitions of natural products, especially of the Dominions, Colonies, and India, and providing for their investigation, and for the collection and dissemination of scientific, technical, and commercial information relating to them.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales (afterwards King Edward VII.) was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned, subject to certain rights of usage by the Imperial Institute, for occupation by the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of

Trade, assisted by an advisory Committee including representatives of the Dominions, Colonies, and India, as well as of the Colonial and India Offices, the Board of Agriculture, and the Board of Trade. This Act took effect on January 1, 1903.

On October 1, 1907, in virtue of an arrangement made with the Board of Trade and with the approval of the Secretary of State for India, the management of the Imperial Institute was transferred to the Secretary of State for the Colonies, subject to the responsibility of the Board of Trade under the Act of 1902. A Committee of Management of three members, one nominated by each of the three Government Departments chiefly concerned, has been appointed, and at present consists of Mr. C. A. Harris, C.B., C.M.G., M.V.O.; Sir Alfred Bateman, K.C.M.G.; and Sir John P. Hewett, G.C.S.I., C.I.E.

The first Director of the Imperial Institute was Sir Frederick Augustus Abel, Bart., G.C.V.O., K.C.B., F.R.S., who held the office until his death in the autumn of 1902. The present Director is Professor Wyndham Dunstan, C.M.G., M.A., LL.D., F.R.S., who was appointed in 1903.

The staff of the Imperial Institute includes officers with special qualifications in the sciences of chemistry, botany, geology, mineralogy, and in certain branches of technology, in their relation to agriculture and to the commercial utilisation of economic products.

A Report by the Director on the Work of the Imperial Institute is presented to Parliament annually.

The following are the principal departments of the Institute:

Public Exhibition Galleries.—The collections of economic products, etc., illustrative of the general and commercial resources of the Dominions, Colonies, and India, are arranged, together with other exhibits, on a geographical

system in the public galleries of the Imperial Institute, which are open free to the public daily, except on Sundays, Good Friday, and Christmas Day, from 10 a.m. to 5 p.m. (10 a.m. to 4 p.m. in winter).

The following British Dominions, Colonies, and Dependencies are represented by Courts, which are in charge of Technical Superintendents:

Canada, Newfoundland; Jamaica, Turks and Caicos Islands, British Honduras, British Guiana, Bahamas, Trinidad and Tobago, Barbados, Windward Islands, Leeward Islands, Bermuda; Falkland Islands; New South Wales, Victoria, Queensland, Tasmania, South Australia, Western Australia, Papua, New Zealand; Fiji, Western Pacific Islands; Union of South Africa, Rhodesia, Nyasaland, St. Helena; Gambia, Sierra Leone, Gold Coast, Nigeria; East Africa Protectorate, Zanzibar and Pemba; Uganda; Somaliland; the Anglo-Egyptian Sudan; Malta; Cyprus; Ceylon; Hong Kong; Mauritius; Seychelles; Straits Settlements, the Federated Malay States; and India.

The Ceylon Pavilion, decorated in Kandyan style and containing pictures of Ceylon and exhibits of native industrial art, has recently been opened. Ceylon tea can be obtained in the afternoon (except in winter) in the Pavilion. The tea served represents the best tea produced in Ceylon.

An official lecturer (Dr. H. B. Gray) has been appointed to deliver short illustrated lectures and to explain the exhibits shown in the various Courts. Visitors and parties from schools will be able to arrange to attend these lectures without charge.

A Central Stand for Publications and an Enquiry Office are maintained in the centre of the main gallery to facilitate the supply of general information and the distribution of literature. Handbooks, pamphlets, circulars,

etc., containing information relating to the commerce, agriculture, mining, and other industries of the principal British Possessions, and also to emigration, are available for gratuitous distribution or for sale. The publications of the Emigrants' Information Office, established by the Colonial Office, may also be obtained. Lists of the publications available for distribution or sale are provided, and the principal Colonial and Indian newspapers may be seen on application.

In 1914 the public galleries were visited by 185,660 persons, and 11,916 Colonial and Indian publications were distributed.

Scientific and Technical Research Department.—The research laboratories and workrooms of this Department were established in order to provide for the investigation of new or little-known natural products from the Colonies and India and of known products from new sources, with a view to their utilisation in commerce, and also to provide trustworthy scientific and technical advice on matters connected with the agriculture, trade, and industries of the Colonies and India.

The work of this Department is chiefly initiated by the Home and Colonial Governments and the Government of India. Arrangements have been also made by the Foreign Office, whereby British representatives abroad may transmit to the Department for investigation such natural products of the countries to which they are appointed as are likely to be of interest to British manufacturers and merchants.

Special analyses and investigations are also undertaken for firms or private persons in any part of the Empire on payment of appropriate charges. Application for such investigations should be made, in writing, to the Director.

Materials are first investigated in the research laboratories of the Department, and are afterwards submitted to

further technical trials by manufacturers and other experts, and finally are commercially valued.

A Reference Sample Room is maintained in this Department, in which are arranged samples of the principal materials which have been investigated and valued commercially during recent years, and as to which full information is available.

The Department works in co-operation with the Agricultural, Mines and other technical Departments in the Colonies, whose operations it supplements by undertaking such investigations as are of a special scientific or technical character connected with agricultural or mineral development, as well as enquiries relating to the composition and commercial value of products (animal, vegetable, or mineral) which can be more efficiently conducted at home in communication with merchants and manufacturers, with a view to the local utilisation of these products or to their export.

A very large number of reports on these subjects have been made to the Governments of the Colonies and India, a first instalment of which was printed in a volume of *Technical Reports and Scientific Papers*, published in 1903. A series of Selected Reports is now being issued in the Miscellaneous Series of Colonial Reports. Of these Selected Reports, five have been published: Part I. "Fibres" (Cd. 4588), Part II. "Gums and Resins" (Cd. 4971), Part III. "Food Stuffs" (Cd. 5137), Part IV. "Rubber and Gutta Percha" (Cd. 6022), Part V. "Oil-seeds, Oils, Fats and Waxes" (Cd. 7260). A further Part dealing with Essential Oils and Spices is in preparation.

Mineral surveys, under the supervision of the Director of the Imperial Institute, and conducted by Surveyors selected by him, are in progress in several countries. All minerals found which are likely to be of commercial importance are forwarded to the Imperial Institute, where

they are examined and their composition and commercial value ascertained. Reports by the Director on the results of mineral exploration in Ceylon, Northern Nigeria, Southern Nigeria, and Nyasaland have been printed in the Miscellaneous Series of Colonial Reports.

Technical Information Bureau.—For some years past a steadily increasing stream of enquiries has been received by the Imperial Institute from manufacturers, merchants, and others, in Great Britain and the Colonies. These enquiries relate principally to new sources of supply of raw materials, methods of utilising new products from the Colonies and India, or to new or little-known processes and machinery for industrial purposes. The number of these enquiries has now become so great that the Secretary of State for the Colonies has authorised the formation of a Technical Information Bureau at the Institute for dealing with them. This Bureau is a special branch of the Scientific and Technical Research Department, and is mainly staffed by experts who have had the advantage of experience in the work of that Department of the Imperial Institute, which is carried on in communication with producers in the Colonies, and with manufacturers and users of raw materials in this country.

The present is a specially opportune moment for the formation of such a Bureau, since the paralysis of German and Austrian trade and industry opens up opportunities for the development of many industries in this country and in the Colonies which have hitherto been monopolised by Germany. The new Bureau is already playing an active part in this work by supplying technical information to enquirers and by issuing special circulars and pamphlets dealing with various problems in connection with raw materials, which have arisen owing to the war. The following circulars can be obtained gratis on application :

(1) New Markets for British, Colonial, and Indian Copra.
(2) Wattle or Mimosa Bark, for Tanning.
(3) The Production and Utilisation of Molybdenite.
(4) New Markets for British, Indian, and Colonial Ground Nuts and their Products.
(5) Plumbago (or Graphite) from Ceylon.

Library, Reading-Rooms, and Map-Room.—The library and reading-rooms of the Imperial Institute contain a large collection of Colonial and Indian works of reference, and are regularly supplied with the more important official publications, and with many of the principal newspapers and technical periodicals of the United Kingdom, the Dominions, the Colonies, India, and Foreign countries.

The Map-Room, which adjoins the reading-rooms, is provided with a large collection of recent maps of the Dominions, the Colonies, and India, which can be seen on application to the Librarian.

The library and reading-rooms are on the first floor, and admittance to them is obtained through the entrance at the west (Queen's Gate) end of the building. These rooms are available for the use of Life Fellows of the Imperial Institute, and of other persons properly introduced. Books and newspapers may be consulted for special purposes by permission.

Tropical African Services Course.—A course of instruction in certain specified subjects is now given at the Imperial Institute to candidates selected by the Colonial Office for administrative appointments in East and West Africa. Instruction in the subject of Tropical Economic Products in this Course is given by a member of the staff of the Imperial Institute.

Colonial Conference Rooms.—Three rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Colonies for meetings and receptions.

The Cowasjee Jehangier Hall.—The Bhownaggree corridor and rooms in connection with this hall are in the occupation of the Indian Section of the Imperial Institute, whilst the hall is available for lectures, meetings, etc.

The "Bulletin of the Imperial Institute" is published quarterly by Mr. John Murray, 50A, Albemarle Street, London, price *2s. 6d.* (annual subscription 11*s.*, including postage), and may be purchased through any bookseller or from agents in the Colonies and India. The BULLETIN contains records of the principal investigations conducted for the Colonies and India at the Imperial Institute, and special articles chiefly relating to progress in tropical agriculture and the industrial utilisation of raw materials (animal, vegetable, and mineral).

Imperial Institute Handbooks on Tropical Resources.—The Secretary of State for the Colonies has authorised the preparation of a series of handbooks dealing with the Commercial Resources of the Tropics, with special reference to West Africa. The handbooks are edited by the Director of the Imperial Institute, and published by Mr. John Murray. The first three volumes are: *The Agricultural and Forest Products of British West Africa*, by Gerald C. Dudgeon, Director-General of Agriculture in Egypt, and lately Inspector of Agriculture for British West Africa, price 5*s.* net; *Cocoa: Its Cultivation and Preparation*, by W. H. Johnson, F.L.S., Director of Agriculture in Southern Nigeria, price 5*s.* net; and *Rubber: Its Sources, Cultivation, and Preparation*, by Harold Brown, Technical Superin-

tendent, Scientific and Technical Department, Imperial Institute, price 6*s*. net. A fourth volume dealing with Vegetable Fibres, by Ernest Goulding, D.Sc., F.I.C., F.C.S., Superintendent, Technical Information Bureau, Imperial Institute, is in preparation.

The following Societies have their offices at the Imperial Institute:

International Association for Tropical Agriculture, British Section.—The object of this Association, the Central Bureau of which is in Paris, is the promotion of the scientific and practical study of all questions connected with tropical agriculture and the development and utilisation of natural resources, especially of tropical countries. The British Section has its headquarters at the Imperial Institute. Members of the British Section are permitted to use the library and reading-rooms of the Imperial Institute. An International Congress of Tropical Agriculture was held under the auspices of the Association at the Imperial Institute from June 23 to 30, 1914, the organisation of which was undertaken by the British Committee. The *Proceedings* of the Congress, including abstracts of the papers supplied by the authors, reports of the discussions, and the inaugural address of the President, Prof. W. R. Dunstan, C.M.G., LL.D., F.R.S., have now been published by Messrs. John Bale, Sons, & Danielsson, Ltd., at the price of 10*s*. net. Postage: Inland, 4*d*.; Abroad, 8*d*.

British Women's Emigration Association.—The British Women's Emigration Association has been assigned offices on the mezzanine floor, which are open daily from 10 a.m. to 4 p.m. Advice and information respecting emigration and prospects for women in the Colonies may be obtained there free of charge. This Association works

in co-operation with the Emigrants' Information Office in Westminster.

Colonial Nursing Association.—An office has been allotted on the mezzanine floor to this Association. The principal object of the Association is the selection of trained hospital and private nurses for service in the Crown Colonies and Dependencies.

Tropical Diseases Bureau.—Temporary office accommodation on the mezzanine floor has been provided for this Bureau, the main purpose of which is to collect information regarding tropical diseases and to distribute it as widely as possible among those who are engaged in combating such diseases.

Universities Bureau of the British Empire.—An office on the mezzanine floor has been allotted to this Bureau, the object of which is the collection and dissemination of information relating to the Universities of the British Empire.

THE IMPERIAL INSTITUTE

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Labour Staff.—*Foreman:* J. Foster.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

WHEAT FROM EGYPT

A CONSIDERABLE amount of wheat is grown in Egypt for local consumption, but only small quantities are at present exported. In 1912–13 the total area under wheat amounted to 1,305,577 feddans (1 feddan = 1·038 acres), or about 17 per cent. of the total area of land under cultivation. The only products grown on a larger area were maize and cotton, which occupied 24 and 22·3 per cent. respectively of the total cultivated area. The area under wheat is about equally divided between Upper and Lower Egypt, the plant being grown as a winter crop. The exports of wheat in 1913 amounted to about 2,400 tons, valued at £21,000, practically the whole being sent to Turkey. In the same year 4,600 tons of wheat, valued at £40,000, were imported to Egypt, mainly from India. In addition large quantities of wheat flour are imported.

On account of the anticipated reduction in the demand for cotton a decree was promulgated in September 1914, which limited the total cotton area of Egypt for 1915 to 1,000,000 acres, *i.e.* three-quarters of the area planted in 1914. The land thus set free was to be sown with cereals in order to make the country more independent of outside supplies, whilst it was anticipated that there would be a surplus which could be exported profitably.

In order to ascertain the suitability of Egyptian wheats for export to the United Kingdom three small samples, which

were stated to be representative of the wheats grown in Egypt, were received for examination in October 1914, and a further sample in January of this year.

The first three wheats, which were stated to be of Indian origin, were described as follows:

1. Hindi wheat, similar to Muzaffarnaggar Indian wheat.

2. Hindi wheat "Saidi."

3. Hindi wheat "Beheri."

The three samples were submitted to commercial experts in London, who were asked for an opinion as to whether similar wheats would be suitable for the British market, and if so what their probable value would be. They furnished the following report on the samples:

No. 1. "*Hindi wheat, similar to Muzaffarnaggar Indian wheat.*"—This is somewhat similar to the "Delhi" wheat which is shipped from Karachi, and would be worth about 51*s.* per quarter of 492 lb. (December 10, 1914), on the terms of the London Corn Trade Association Contract Form No. 1 for East Indian wheat.

No. 2. "*Saidi.*"—A wheat of good colour, but rough, thick-skinned, starchy, and lacking strength; weaker than No. 1, and worth about 49*s.* 6*d.* per 492 lb. (December 10, 1914), on the terms mentioned above.

No. 3. "*Beheri.*"—A large berried, but very rough wheat, thick-skinned, starchy, and lacking strength. It would be worth about 48*s.* per 492 lb. (December 10, 1914), on the same terms as Nos. 1 and 2.

It was stated that the "Saidi" and "Beheri" wheats are not unknown to London corn factors and millers, having been exported from Egypt some twenty-five to thirty years ago in considerable quantities under the names of "Saidi" and "Beira" wheats.

All three wheats would be quite suitable for the English market, and consignments of similar character would be saleable at prices dependent upon the current market values.

The fourth sample represented a type known as "Gawi," which is in much favour in parts of Upper Egypt, owing to its power of resisting the hot "Khamseen" winds of

March and April. It is believed to be of Algerian origin. The experts in London stated that this wheat would not be suitable for the British markets. It resembled in character the hard Bombay wheats which are used for the manufacture of macaroni, and it would find much better markets at Mediterranean or Adriatic ports than in the United Kingdom.

THE ESSENTIAL OIL OF SHERUNGULU TUBERS

The Sherungulu tubers which are the subject of this report were received at the Imperial Institute from South Africa in July 1911. A previous investigation of the tubers at the Imperial Institute had shown that they contain a small quantity of volatile oil, and a further supply of the material had accordingly been requested in order that a complete examination of the oil might be made, and the possibility of its utilisation in perfumery determined.

The plant yielding the Sherungulu tubers has been identified as *Kaempferia Ethelae*, J. M. Wood.

The tubers as received at the Imperial Institute were found to contain 25 per cent. of moisture, and when submitted to steam distillation they yielded a quantity of volatile oil amounting to 1·5 per cent. expressed on the moist material, or 2·0 per cent. expressed on the dry material. This yield agrees closely with that furnished by the first sample, which gave 1·9 per cent. of oil from the dry tubers.

Of the total distillate, 93 per cent. consisted of a light oil, which was of pale yellowish-brown colour and had a rather pleasant odour, somewhat resembling that of orange-flower oil combined with a less agreeable smell. The remaining 7 per cent. of the oil was, when first distilled, a dark brown, viscous liquid, with an odour recalling that of crushed ivy leaves.

Light Oil.—The light oil furnished the following results on examination :

Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·9437
Optical rotation in 100 mm. tube at 22° C.	+ 19° 47′
Acid value	2·3
Ester value	5·0
" after acetylation	47·6

A detailed examination of the light oil was made in order to determine its constituents, with the result that it was found to contain terpenes (including dipentene and probably pinene), cineole, linalool, and esters (principally methyl methylanthranilate), together with a new ketonic compound.

Heavy Oil.—This oil gradually became semi-solid on keeping, owing to the separation of a crystalline substance which proved to be identical with the ketone found in the light oil. After the crystals had been removed, the residual heavy oil appeared to consist of a solution of the ketone in certain high-boiling liquid constituents, probably sesquiterpenes.

The results of this investigation indicate that the volatile oil yielded by the tubers of *Kaempferia Ethelae* has approximately the following composition:

	Per cent.
Terpenes, including dipentene and probably pinene	21·8
Cineole	17·2
New ketonic compound	13·0
Alcohols, including linalool	11·2
Esters, chiefly or entirely methyl methylanthranilate	1·3
Phenols	0·5
Acids, chiefly or entirely acetic acid	0·1
Residue, probably chiefly sesquiterpenes	34·9

This investigation of the volatile oil obtained from Sherungulu tubers has established its composition, and as soon as a further supply is available it will be possible to consider the further question as to whether the oil can be used commercially for any purpose.

The oil is of considerable scientific interest, and a paper dealing with its constituents has been communicated to the Chemical Society of London by Dr. E. Goulding, F.I.C., and Mr. O. D. Roberts, A.I.C., of the Scientific and Technical Department of the Imperial Institute.

CASTILLOA RUBBER FROM INDIA

Two samples of Castilloa rubber from India, one obtained from male trees and one from female trees, were received for examination in July 1914. The plants were grown experimentally at the Bassein Botanical Gardens, Bombay, having been sown in the nursery on May 20, 1907, and transplanted on June 17, 1908. The trees were watered at long intervals up to 1913, when watering was stopped.

No information was supplied as to the yield of rubber in the present instances, but it may be mentioned that, according to the *Annual Report on the Experimental Work of the Gardens* for 1911–12, a single tree was tapped in that year and yielded ½ oz. of rubber.

The samples were as follows:

No. 1. *From Male Trees.*—Small irregular balls of dark coloured scrap rubber containing a little vegetable impurity. The physical properties of the rubber were fairly good.

No. 2. *From Female Trees.*—Similar in appearance to No. 1, but softer and weaker.

The specimens were analysed with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*
Loss on washing (moisture and impurities)	7·5	5·3
Composition of dry, washed rubber:		
Caoutchouc	81·6	60·9
Resin	12·4	34·3
Proteins	4·7	3·7
Ash	1·3	1·1

Rubber of the quality represented by sample No. 1 would probably be worth about 1*s.* 6*d.* per lb. in London, with fine hard Para at 2*s.* 6*d.* per lb., and fine plantation Para at 2*s.* 4*d.* per lb., whilst that represented by sample No. 2 would probably be worth about 3*d.* per lb. less.

Sample No. 1, derived from male trees, is much superior in composition to sample No. 2, derived from female trees, as it contains only 12·4 per cent. of resin as compared with 34·3 per cent. It is also more satisfactory in physical properties.

If the rubber could be prepared in the form of sheet it

would be more valuable than balls of scrap rubber similar to the samples, but the possibility of making sheet rubber will depend on whether the latex flows sufficiently freely at any season of the year to allow of its collection in bulk for subsequent coagulation. In the present case it was stated that the latex was thick and that it coagulated quickly on the tree and was ready for collection the day after tapping.

RUBBER FROM DOMINICA

SEVERAL species of rubber trees have been introduced into Dominica with a view to the establishment of a rubber planting industry. *Castilloa elastica* is said to thrive excellently, but the yield of rubber is low and its cultivation is not recommended. A specimen of the rubber prepared from trees growing at the Botanic Station was examined at the Imperial Institute some years ago and it proved to be of good quality, being valued at 3*s.* 6*d.* per lb. in London with fine hard Para at 4*s.* 3½*d.* per lb. (see this BULLETIN, 1910, **8**, 126). *Funtumia elastica* has given promising results under certain conditions, but its general cultivation is not recommended. *Hevea brasiliensis* on the other hand has done well, and it is stated that there are prospects of a considerable development in its cultivation in the near future if seeds can be obtained in sufficient quantities and successfully germinated (*West Indian Bulletin*, 1912, **12**, 16). It was estimated that about 200 acres were planted with Para rubber in the island in 1912. Large numbers of plants have been distributed from the Botanic Station, whilst a number have also been raised by planters. *Ficus elastica* has also been grown in the Botanic Station, but it is only suitable as wind-belts or on steep hillsides, which have in many instances been cleared and afterwards found too steep for cocoa and lime cultivation.

Three samples of Para rubber and one of Funtumia rubber, prepared at the Botanic Station, were received at the Imperial Institute in July 1914, and these were examined with the following results :

Para Rubber

No. 1. "Para biscuits."—Thin biscuits of pale rubber, clean and well prepared. The rubber was of good appearance but was rather soft and deficient in tenacity. Many of the biscuits were firmly stuck together.

No. 2. "Para biscuits, 2nd quality."—Thin biscuits, varying in colour from pale to light brown, and not of such good appearance as the preceding sample. The rubber was soft and deficient in tenacity. Many of the biscuits were firmly stuck together.

No. 3. "Para rubber (smoked)."—Thin biscuits of dark brown rubber having a strong smoky odour. The physical properties were a little better than those of the preceding samples, but the rubber was still rather weak.

The samples were analysed with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*	No. 3. *Per cent.*
Loss on washing (moisture and impurities)	0·3	0·2	0·4
Composition of dry, washed rubber:			
Caoutchouc	93·5	94·2	93·4
Resin	3·5	3·3	4·4
Proteins	2·7	2·2	2·0
Ash	0·3	0·3	0·2

The rubber was valued as follows: No. 1 2*s.* 1*d.* per lb., No. 2 2*s.* 0*d.* per lb., and No. 3 2*s.* 3*d.* per lb., with first-quality biscuits at 2*s.* 4*d.* and first-quality smoked biscuits at 2*s.* 6*d.* to 2*s.* 7*d.* per lb.

It will be seen that these three samples of Para rubber from Dominica were very satisfactory in chemical composition, containing from 93·4 to 94·2 per cent. of caoutchouc. In physical properties, however, the rubber was not so good, being rather soft and weak, and in this respect the specimens were a little inferior to previous samples of Para rubber from Dominica examined at the Imperial Institute (see this Bulletin, 1910, **8**, 127; 1912, **10**, 555).

Funtumia Rubber

This sample consisted of thin rough biscuits of light brown rubber, clean and in good condition. The physical properties of the rubber were excellent.

It was examined chemically with the following results:

	Per cent.
Loss on washing (moisture and impurities)	1·2
Composition of dry, washed rubber:	
Caoutchouc	84·6
Resin	8·8
Proteins	6·4
Ash	0·2

This rubber was valued at about 2*s.* per lb. (November 1914).

It contained rather large percentages of resin and protein, with the result that the amount of caoutchouc in the dry rubber is only 84·6 per cent. Its physical properties were however very satisfactory, and similar rubber would always be readily saleable.

FIBRES FROM VARIOUS SOURCES

In the following pages an account is given of the results of examination of some well-known fibres from new sources, which have been received at the Imperial Institute recently.

Sisal Hemp from Egypt

The three samples of Sisal hemp which are the subject of this report were received at the Imperial Institute in October 1914. They were grown on the State Domains in Egypt, and it was desired to ascertain the commercial value of the fibres, and whether they were of sufficiently good quality to find a constant market in competition with Sisal hemp from other sources.

The samples were as follows:

No. 1.—Coarse, lustrous, pale yellow fibre, varying in length from 3 ft. 4 in. to 3 ft. 7 in., well cleaned and prepared, and of excellent strength.

No. 2.—Coarse, lustrous fibre, similar to No. 1 but slightly paler in colour. The fibre varied in length from 3 ft. 4 in. to 4 ft. It was well cleaned and prepared, and of very good strength.

No. 3.—This fibre was similar to No. 2, but somewhat whiter and finer. It varied in length from 2 ft. 6 in. to 3 ft., and was of good strength.

Samples Nos. 2 and 3 were too small for chemical examination, but sample No. 1 was submitted to analysis

with the following results, which are shown in comparison with the corresponding figures for samples of Sisal hemp from the East Africa Protectorate and Papua previously examined at the Imperial Institute:

	Present sample from Egypt.	Sample from East Africa Protectorate.	Sample from Papua.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·8	11·1	9·1
Ash	0·76	1·0	0·6
α-Hydrolysis, loss	9·1	11·2	9·0
β-Hydrolysis, loss	11·0	14·1	11·7
Acid purification, loss	1·1	2·3	1·2
Cellulose	79·4	78·2	79·9

The above results indicate that the Sisal hemp from Egypt is of excellent quality and well cleaned. The losses on α- and β-hydrolysis and on acid purification are low, and the percentage of cellulose is high.

The three samples were submitted for valuation to fibre merchants, who reported that No. 1 would be worth about £27 per ton, No. 2 £28 per ton, and No. 3 £25 per ton, c.i.f. London, with Mexican Sisal at £20 per ton. They added that all three fibres would be readily saleable in large quantities at the prices ruling for East African Sisal hemp.

These three samples are all of excellent quality, and will bear comparison with the highest grades of Sisal hemp from other countries. No difficulty would be experienced in disposing of consignments of similar character.

Mauritius Hemp from Rhodesia

Two samples of Mauritius hemp (*Furcraea gigantea*) were received for examination in November 1914. They were as follows:

No. 1.—Well prepared fibre, not very uniform in appearance, and varying in colour from nearly white to pale brown. Some of the material was dull, and some fairly lustrous. It was rather weak and varied from 3 ft. 6 in. to 4 ft. 6 in. in length, with an average of about 4 ft.

No. 2.—This was similar to the preceding sample, but was nearly white, of uniform appearance and of fair lustre. It was also rather weak and about 6 in. shorter than No. 1.

The two samples were submitted to chemical examination with the following results, compared with samples of Mauritius hemp from Southern India and Nyasaland, previously examined at the Imperial Institute:

	No. 1.	No. 2.	Sample from Southern India.	Sample from Nyasaland.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	11·5	10·1	9·8	8·7
Ash	1·5	1·4	—	1·1
α-Hydrolysis, loss	12·7	14·0	12·4	10·0
β-Hydrolysis, loss	17·7	16·4	14·5	14·5
Acid purification, loss	0·4	1·7	1·7	1·7
Cellulose	79·3	77·6	77·7	75·8

Sample No. 1 was fairly well prepared, but the colour and cleaning could both be improved. It was valued by fibre merchants at £23 to £24 per ton, ex warehouse, London (January 1915). The second sample would have about the same value. If properly washed and prepared the fibre would be considered as of "prime" quality, and worth about £27 per ton, ex warehouse, *i.e.* about the price of "prime" Mauritius hemp in London in normal times.

Hibiscus cannabinus Fibre from Rhodesia

A sample of *Hibiscus cannabinus* fibre grown in Rhodesia was received for examination in November 1914. It was rather harsh and coarse, but fairly lustrous, and varied in colour from a very pale straw tint to brown. The fibre was imperfectly retted in parts, and was somewhat gummy. It was of fair strength, and varied in length from 3 ft. 6 in. to 5 ft., but was mostly about 4 ft.

The fibre was examined with the following results compared with samples of Bimlipatam jute from India, and "extra fine" Indian jute:

	Present sample.	Bimlipatam jute from India.	"Extra fine" Indian jute.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	9·6	12·5	9·6
Ash	1·2	1·3	0·7
α-Hydrolysis, loss	11·6	11·8	9·1
β-Hydrolysis, loss	15·2	15·1	13·1
Acid purification, loss	0·8	—	—
Cellulose	74·3	75·4	77·7

The sample was submitted to fibre merchants, who reported that the material was similar to Calcutta jute, but was very imperfectly prepared, probably through under-retting. They stated that in this condition the fibre would be difficult to sell and only worth about £15 per ton; but that if properly prepared it would be worth from £18 to £19 per ton, ex warehouse London (January 1915). The fibre of *H. cannabinus* from India sells as "Bimlipatam jute," generally at a figure somewhat below the current price of true jute. On the date of the above valuation "first native marks" Calcutta jute was quoted in London at £18 per ton.

Good quality jute in normal times realises about £15 to £20 per ton, but the price is subject to wide variation.

Manila Hemp from the Solomon Islands

A sample of Manila hemp prepared in the Solomon Islands from plants of *Musa textilis*, introduced from the Philippine Islands, was received for examination in October 1913. It consisted of very lustrous fibre, well cleaned and prepared, but slightly irregular in colour, varying from pale cream to a straw tint. The strength was rather irregular, but on the whole was good. The fibre varied in length from 6 ft. to 10 ft., but was mostly from about 6 ft. to 8 ft.

The fibre was examined with the following results, compared with those given by a standard sample of Manila hemp:

	Present sample.	Standard Manila hemp.
	Per cent.	*Per cent.*
Moisture	10·9	10·2
Ash	1·7	1·1
α-Hydrolysis, loss	12·9	11·2
β-Hydrolysis, loss	18·6	17·8
Acid purification, loss	2·6	1·6
Cellulose	75·7	78·6

A specimen of the fibre was submitted to commercial experts who valued it at about £50 per ton, with "fair

current" Manila hemp at £28 10s. per ton, and "good current" at £60 10s. per ton.

This fibre was of very good quality, and would be readily saleable in large quantities in the United Kingdom. It resembled "superfine" Manila hemp in appearance, but its average strength was rather less owing to the presence of some thin, weak strands.

BOXWOOD (*BUXUS MACOWANI*) FROM SOUTH AFRICA

THE Cape box (*Buxus Macowani*, Oliv.) is a small tree which inhabits the forests within 20 miles of the sea, from Alexandria to West Pondoland, in the Cape Province (Sim, *The Forests and Forest Flora of the Colony of the Cape of Good Hope*, 1907, p. 321). Occasionally, as at East London, it forms pure forest, but its distribution is local, being determined by the character of the underlying rocks. The stems are usually 6 to 9 in. in diameter and from 10 to 20 ft. in height, having a single straight bole. Prior to 1884 the wood was used only as fuel, but since that year the tree has been preserved in the Crown Forests, and the timber has been exported to some extent, although none appears to have been shipped in recent years. The boxwood at present exported from the Cape Province is derived from *Gonioma Kamassi*, E. Mey., and is often known as Knysna boxwood from the name of the port of shipment; the value of the exports of this wood in 1913 amounted to £3,196, that sent to the United Kingdom being valued at £1,954. According to Sim (*loc. cit.* p. 323) the total export of "boxwood" up to the end of 1899 amounted to 264,072 cub. ft. (about 6,770 tons), of the declared value of £19,719; this was made up of 135,260 cub. ft. (£9,135) of true Cape boxwood from Alexandria and East London, and 128,812 cub. ft. (£10,574) of *Gonioma Kamassi* wood from Knysna.

In order to ascertain the properties and commercial value of the timber of *B. Macowani* in comparison with European boxwood (*B. sempervirens*), with a view to re-

introducing it to the English markets, a small consignment of the wood was received at the Imperial Institute from South Africa in October 1914.

The consignment consisted of four logs, each measuring about 4 ft. in length, with an average diameter of about 6 in.

One of the logs was selected for technical examination with a view to the determination of its working qualities in comparison with those of European boxwood. The wood was of good uniform colour, but slightly paler than the European variety. It weighed 62 lb. per cubic foot. It was found to saw, plane, and work much like European box, the chief difference being that it is less dense and hard; it is, however, somewhat tougher, and would thus be less liable to chip from shock. Like most hard woods it polishes satisfactorily, and for a wood of its density it takes glue well.

The logs were received at the Imperial Institute in an unseasoned condition, but a prepared specimen of the wood and other cut pieces which have been kept under ordinary atmospheric conditions for three months have shown no indication of splitting and but little sign of warpage. European boxwood is said to be very liable to split badly during the process of seasoning, which takes three or four years from the time of felling, and if this South African boxwood can be seasoned without developing this fault, its value should be greatly enhanced.

Samples of the boxwood were submitted to firms of engraving-block manufacturers, bobbin and shuttle manufacturers, wood turners, and timber merchants, who reported as follows:

(*a*) The engraving-block manufacturers stated that, judging from a preliminary inspection of the sample, the wood could only be used for the cheap class of wood engraving, but that a better opinion could be formed in a few months' time when the wood had become drier. These trials are still in progress.

(*b*) The bobbin and shuttle manufacturers reported that they had carefully tested the sample submitted to them. They stated that this particular kind of boxwood has from time to time been used in their trade, but only to a limited

extent. As regards weight it is no better than West Indian boxwood, and it does not yield such large pieces free from defects; for turning, it is too soft to be very useful for their purposes.

With reference to the probable value of the wood, the firm pointed out that the price of West Indian boxwood was not more than £5 to £5 5*s*. per ton delivered in Liverpool (October 1914).

(*c*) The wood turners reported that they had tested the South African boxwood in turning and screwing, and that it seemed to behave quite satisfactorily. They stated that the appearance of the end grain resembled that of Turkish boxwood, which is usually considered to be the best variety, and they were of opinion that this South African boxwood could probably be used for a number of purposes for which Turkish boxwood has hitherto been employed. They stated that in any case it would be very suitable for their particular purposes.

The firm enquired as to whether this timber was likely to be imported into the United Kingdom, and if so, at what price it could be offered.

(*d*) The merchants who were consulted reported that ten or twelve years ago this boxwood was sold in London as "East London boxwood," a name which is also applied to the wood of *Gonioma Kamassi*, the Knysna boxwood. It was then considered unsuitable for some of the purposes to which ordinary boxwood is generally applied, but it was utilised in the north of England for making rollers used in certain kinds of machinery. At that time pieces of the wood about 2¼ to 4½ in. in diameter realised about £6 per ton, whilst smaller pieces, about 1 to 2 in. in diameter, were also occasionally sold at about £5 per ton.

The firm stated that a drawback to this wood is that it is somewhat softer than ordinary boxwood, and is therefore not so suitable for engraving and similar work. They added, however, that the present sample had worked up satisfactorily and had given better results than had been expected. In view of this and the fact that the supply of boxwood from the chief source, the Black Sea, is likely to be interrupted for a considerable period, they were of

opinion that the present time would be a favourable opportunity to make a fresh endeavour to introduce this South African boxwood on the English market. They considered that the best plan would be to ship to London a consignment of about 10 tons, made up of assorted sizes, from about 1 up to 4 in. in diameter. It would, however, be useless to incur freight and other charges on pieces of inferior character, such as twisted, knotty, and split wood, and a selection should therefore be made and the poor wood rejected.

The merchants stated that if the logs are round, of regular growth, and sound and fairly free from knots, there is no reason why about £7 per ton should not be obtained in London for logs of small dimensions, say up to 2½ in. in diameter, and about £10 per ton for logs from 3 to 4 in. in diameter. These prices, which are purely nominal, are quoted for the wood landed in the London docks, and are subject to 2½ per cent. discount, and 2½ per cent. brokerage and del credere, whilst the landing charges amount to approximately 10*s.* to 12*s.* per ton. Later on the wood, if it finds a regular market, could be sold on c.i.f. terms, and the landing charges avoided.

The firm in conclusion pointed out the importance of cutting the wood when the sap is down, stating that if cut at the wrong time it would be very liable to split and discolour.

Conclusions

The results of this investigation indicate that the timber of *Buxus Macowani* from South Africa could be utilised in the United Kingdom for some of the purposes for which European boxwood is employed. In order to test the market it was suggested that a trial shipment of about 10 tons should be forwarded to the Imperial Institute for sale by brokers in London. Information has also been requested as to the quantity of the wood which could be regularly shipped.

INVESTIGATIONS OF VEGETABLE DRUGS AND POISONOUS PLANTS

In the following pages an account is given of the results of investigation of various drugs and poisonous plants received in recent years. These products have been examined either by the staff of the Scientific and Technical Research Department of the Imperial Institute, or by other investigators, with material supplied by the Institute.

The drugs examined include many "native drugs," that is, products which have a reputation as medicines among natives. As a rule these drugs are disappointing from the standpoint of practical medicine. It will be seen that of the considerable number now dealt with, few have given results at all commensurate with the labour expended on examining them. It seems worth while, however, to place these results on record as of possible scientific interest, though not of medical importance. Two instances of drugs proving to be of importance are included. The first of these is the Indian plant *Podophyllum Emodi*, which, as the result of investigations carried out at the Imperial Institute, has been recognised in the British Pharmacopœia recently issued. The second is the Egyptian plant, *Hyoscyamus muticus*, which was first investigated at the Imperial Institute in 1899 and shown to be a valuable source of the alkaloid atropine. This plant has acquired great importance since the outbreak of the war as a source of this alkaloid, and the attention of British manufacturers has again been called to it and arrangements have been made for its supply from Egypt.

As the Imperial Institute is constantly receiving native drugs for examination, especially from British tropical possessions, some observations may usefully be made here as to drugs which are worth examination. It is most desirable that native statements as to the medicinal value of a drug should be tested in the country itself by a European medical officer, and the product should only be sent for examination when the accuracy of the native statements can be confirmed. It is also desirable that the botanical source of the drug should be ascertained, so that

the same material can always be collected with certainty. When this is not known, the first step should be to collect botanical specimens of the plant, showing at least flowers and leaves in good condition, so that it may be identified. If these two precautions are taken a great deal of labour in the chemical and physiological examination of native drugs can be saved.

In the summaries of results now recorded it may be pointed out that for the reasons already given many of the products have been submitted to a preliminary examination only. It is possible that material collected from the same plant at a different stage or in better condition may yield more definite results, but it is believed that enough has been done in each case to ascertain whether the product is likely to have any value in European medicine.

The Imperial Institute is very much indebted for assistance in this work to the various pharmacologists who are referred to later on, and more especially to Dr. J. T. Cash of Aberdeen University, Prof. Cushny of University College, London, and to the Director and Staff of the Wellcome Physiological Research Laboratories.

Hyoscyamus muticus from Egypt

The sample of *Hyoscyamus muticus*, Linn., which is the subject of this report, was received at the Imperial Institute in October 1914.

It was largely composed of stems varying from ¼ to ½ in. in diameter; about one-third of the sample consisted of broken leaves and small stems, and a quantity of flowering heads was also present.

The material as received was found to contain 8·28 per cent. of moisture.

A gravimetric determination of the amount of alkaloid present showed that the material as received contained 0·58 per cent. of total alkaloid, equivalent to 0·64 per cent. in the dry material. A volumetric estimation by the method of the United States Pharmacopœia gave 0·51 per cent. of total alkaloid in the material as received, equal to 0·56 per cent. in the dry material.

The total alkaloid was easily obtained in a crystalline condition, and subsequent examination proved it to consist entirely of hyoscyamine.

These results, both as regards the amount and nature of the total alkaloid, agree with those previously obtained at the Imperial Institute, when this plant was first examined in 1899 (*Trans. Chem. Soc.*, 1899, **75**, 72; 1901, **79**, 71).

At that time the Imperial Institute drew the attention of British alkaloid manufacturers to the value of *H. muticus* as a source of hyoscyamine or atropine, and as a result several consignments of the plant were sold in the United Kingdom. It is understood that one or two firms have continued to obtain supplies of the plant from Egypt.

On the present occasion samples of the plant have been distributed to a number of the principal British firms interested in the production of alkaloids, with a statement giving the results of its examination at the Imperial Institute, and an intimation that supplies were available in Egypt for export. All the firms consulted expressed great interest in the material and a desire to obtain supplies for manufacturing purposes. They were accordingly referred to an exporter in Egypt whose name has been supplied by the authorities in Cairo.

There is no doubt that the Egyptian *H. muticus* is a valuable source of hyoscyamine or its isomeride atropine, and no difficulty should be experienced in finding a ready sale for it in the United Kingdom.

This drug is obviously of great importance at the present time, when atropine has become very scarce and dear owing to the failure of continental supplies.

Bark and Fruits of *Strychnos Henningsii* from South Africa

Specimens of the bark and fruit of *S. Henningsii*, Gilg, the "hard pear tree," were received from South Africa in December 1913 and July 1914 respectively. The bark has a peculiar bitter taste, and is said to be freely used in Eastern Pondoland in the preparation of an "appetizer bitter" by extraction with alcohol. Natives commonly also

use it medicinally and in veterinary practice. The fruits do not appear to be utilised in any way by the natives.

The samples were as follows:

Bark.—The sample consisted of fragments of varying size, having a maximum thickness of ¼ in. The outer surface was fairly smooth and of a light brown colour, whilst the inner surface was longitudinally fluted and of a buff colour. The bark was hard, dry, and brittle, and had a pronounced bitter taste.

Fruits.—The fruits were uniform in size and of oval shape, measuring $\frac{11}{16}$ in. in length, and from ½ to $\frac{9}{16}$ in. in breadth; externally they varied in colour from light chestnut to dark brown. The outer layer consisted of shrivelled pulpy material, and each fruit contained a single seed which had a thin seed coat. The kernel was fairly hard and resembled a coffee bean in size and colour; it possessed a distinctly bitter taste.

An examination of the specimens gave the following results:

Bark.—A preliminary chemical examination of the bark indicated that it contained a large amount of alkaloid. A quantitative determination showed that the bark as received contained 4·8 per cent. of alkaloid, equivalent to a yield of 5·3 per cent. from the dry bark.

On distilling off the solvent used for its extraction, the alkaloid was obtained in the form of a transparent, slightly coloured, gummy residue, which was easily soluble in alcohol, chloroform, benzene, or acetone; partially soluble in ether, and insoluble, or nearly so, in light petroleum or water.

Attempts to crystallise the alkaloid have unfortunately not proved very successful, as despite numerous trials by different methods only in one instance were a few crystals obtained. These consisted of white rosettes of needles showing a well-defined structure. The melting point of these crystals was indefinite, shrinking and decomposition taking place between 260° and 270° C. The crystals had a pronounced bitter taste.

Attempts were also made to prepare crystalline salts of the alkaloid, but with no better success. The only salt

which was obtained crystalline was the sulphate, and even in this case the greatest difficulty was experienced in getting the salt to crystallise.

Fruits.—The thin seed coats and the outer pulpy material were separated from the kernels. The relative proportions of the husks (seed coats and outer covering) and kernels were as follows :

	Per cent.		Per cent.
Husks . . .	57·4	Kernels . . .	42·6

Preliminary tests indicated that the kernels contained an appreciable amount of alkaloid, whereas only a small amount was present in the husks. Quantitative determinations gave the following results :

	Yield of alkaloid. Per cent.		Yield of alkaloid. Per cent.
Husks (moist) . .	0·16	Kernels (moist) . .	4·0
„ (dry) . .	0·18	„ (dry) . . .	4·4

The alkaloid obtained from the kernels appeared to be the same as that obtained from the bark, but attempts to crystallise it or to obtain a crystalline sulphate proved unsuccessful. The amount of alkaloid obtained from the husks was too small for examination.

The husks also contained an orange-red fat which was solid at the ordinary temperature. The moist husks contained 4·9 per cent. of this fat, equivalent to a yield of 5·5 per cent. from the dry material.

The kernels furnished a liquid oil of a pale brownish-orange colour. The yield was 17·6 per cent. from the moist kernels or 19·3 per cent. from the dry kernels.

Very little work appears to have been done on the constituents of the African species of *Strychnos*, and it is not possible at present to make any suggestion regarding the nature of the alkaloid present in *S. Henningsii*. It may however be stated that the reactions of the alkaloid do not agree with those of strychnine or brucine, the characteristic alkaloids of *S. Nux Vomica* and *S. Ignatii*.

The chemical investigation of *S. Henningsii* is being continued, with a view to obtaining the alkaloid in crystalline form and determining its nature and physiological action.

Zanthoxylum brachyacanthum Bark from Queensland

The genus *Zanthoxylum* (including *Fagara*) (Nat. Ord. Rutaceæ) comprises a large number of species, most of which are found in the tropics, but a few occur in temperate regions in North America and Eastern Asia. The barks of a number of the species are used in medicine in different parts of the world, those of *Z. americana*, Miller, and *Z. Clava-Herculis*, L., being official in the United States Pharmacopœia. The barks of these species are used as a remedy in chronic rheumatism, are capable of being used as counter-irritants, and form a popular remedy for toothache in the United States. The bark and wood of *Z. veneficum*, Bailey, which occurs in Australia, are stated to be violent convulsive poisons, and *Z. scandens* is said to be used by the natives of Java as a fish poison. Some species yield valuable timber, West Indian satin wood being derived from *Z. flavum*, whilst that of *Z. brachyacanthum* (thorny yellow wood), a small tree indigenous to northern New South Wales and Queensland, is bright yellow, soft, silky, close-grained, and easily worked and suitable for cabinet work. The West Indian satin wood contains an irritant substance and from material examined at the Imperial Institute several constituents were isolated and specimens of these are being examined physiologically by Professor Cash of Aberdeen University (see this Bulletin, 1912, **10**, 297). The fruits of *Z. piperitum*, DC., the Japanese pepper, are used as a condiment.

A sample of the bark of *Z. brachyacanthum* from Queensland was received in July 1910 and one from New South Wales in April 1912. The investigation of the constituents of this material was undertaken for the Imperial Institute by Dr. H. A. D. Jowett of the Wellcome Laboratories, Dartford, Kent, who has published, with Dr. F. L. Pyman, a paper on the alkaloids found in the bark (*Journ. Chem. Soc.*, 1913, **103**, 290).

Two alkaloids were isolated; one, which was obtained in the form of its chloride, was present to the extent of 1·85 per cent., and the other in only small quantity (0·06 per cent.). The former was proved to be *l-a*-canadine metho-

chloride. The physiological action of this salt, as well as that of the isomeric β-methochloride, were investigated by Dr. P. P. Laidlaw of the Wellcome Physiological Research Laboratories. On the frog neither substance caused local or general anæsthesia, but a gradual paralysis of all voluntary muscle developed similar to that produced by curare and ammonium bases generally. The β-methochloride was found to be much more active than the α-form in this respect, whilst the β-salt was shown to be twelve times as powerful in producing the typical curare effect. On mammals also the two alkaloids were found to have actions very similar to those of curare. They cause large falls of blood pressure and paralyse the ganglion cells of the vagus nerve, and in toxic doses produce paralysis of the respiratory centre. In all these actions also the β-methochloride was very obviously more active than the corresponding α-compound.

The second alkaloid isolated from the bark was found to agree closely in its chemical and physiological properties with those given by the well-known alkaloid γ-homochelidonine, and there can be no doubt as to its identity with this alkaloid. The main features of the physiological actions of this alkaloid are described by E. Schmidt (*Arch. Pharm.*, 1893, **231**, 143) on the authority of H. Meyer.

Daphnandra micrantha Bark from Australia

Daphnandra micrantha, Benth. (Nat. Ord. Monimiaceæ) is a large tree found in the Moreton Bay district of Queensland and in the neighbourhood of the Clarence, Richmond, and Lansdowne Rivers, New South Wales. The barks of this and other species of *Daphnandra*, all of which are confined to Australia, were examined some years ago by Dr. T. L. Bancroft, who found them to contain several alkaloids which were respiratory and cardiac poisons. It was suggested that the plants of the genus might be of medicinal value, and with a view to determining this two samples of the bark of *Daphnandra micrantha* were forwarded to the Imperial Institute by the Director of the Botanic Gardens, Sydney, New South Wales, the first,

which had been collected by Dr. Bancroft, in 1902, and the second in 1911. The first sample was submitted to preliminary examination at the Imperial Institute, and the presence of an alkaloid was confirmed, but owing to pressure of other work the investigation could not be continued, and a supply of the bark was furnished to Dr. H. A. D. Jowett for examination, to whom also the second sample was sent. The results of this examination have been communicated to the Chemical Society of London in a paper by Dr. F. L. Pyman of the Wellcome Laboratories, Dartford (*Journ. Chem. Soc.*, 1914, **105**, i. 1679).

Three new alkaloids were isolated in a pure state and characterised, the total amount of alkaloids being more than 6 per cent. When working with small quantities of bark, 2 per cent. of non-phenolic and 1·5 per cent. of phenolic alkaloids were isolated in a crystalline condition. The crystalline, non-phenolic alkaloids, were separated into two individual bases, for which the names daphnandrine and micranthine are suggested, whilst the crystalline phenolic alkaloid was found to be homogenous, and for this the name daphnoline is proposed. Daphnandrine is most abundant, representing more than three-quarters of the 2 per cent. of non-phenolic alkaloids.

The physiological action of the Daphnandra alkaloids was investigated by Dr. H. H. Dale, F.R.S., of the Wellcome Physiological Research Laboratories, who found that all three appear to have an action of the same type, although daphnandrine is only very slightly active. Daphnoline and micranthine, which show the action more typically, produce a marked local action when injected hypodermically, causing great œdematous infiltration of the subcutaneous tissues and loss of sensibility. They have also a depressant action on the central nervous system, causing anæsthesia, which seems to precede the loss of motor activity to a slight extent in onset. Both cause vasodilator circulatory depression when given intravenously. Death from a fatal dose is due to respiratory paralysis.

Peganum Harmala Seeds from India

Peganum Harmala, L. (Nat. Ord. Zygophyllaceæ) is a much-branched bushy herb 1 to 3 ft. in height found in North-Western India, Arabia, Siberia, Asia Minor, Egypt, North Africa, and South Europe. The seeds have been employed from the earliest times in Eastern medicine as a stimulant, anthelmintic, and narcotic. They contain two alkaloids, harmaline and harmine, the total yield of alkaloids according to Fritzsche being 4 per cent., of which two-thirds is harmaline. They also yield a red dye which was at one time imported to this country from the Crimea.

A detailed investigation of the alkaloids present in *P. Harmala* seeds has been undertaken by Prof. W. H. Perkin, Jun., F.R.S., a supply of seeds for this purpose being obtained from India, at the instance of the Imperial Institute. The first of a series of papers on the results of this investigation, by Prof. Perkin and Mr. R. Robinson, has been published in the *Journ. Chem. Soc.* (1912, **101**, 1775) in which the chemical constitution of harmaline and harmine is dealt with.

Several grams of each of the alkaloids, prepared from this seed, were furnished to Dr. James A. Gunn, of the Pharmacology Laboratory, University of Edinburgh, who conducted experiments on their pharmacological actions. (*Trans. Roy. Soc. Edinb.*, 1910, **47**, ii. 245; 1912, **48**, i. 83.) It was found that harmaline differs from most alkaloids in that it does not exert, to the same extent as they do, a selective action on one kind of tissue. It attacks not only highly specialised tissue, such as voluntary muscle, muscle of the heart, blood-vessels, and cells of the central nervous sytem, but also less highly differentiated cells, such as protozoa, pigment cells, and ciliated epithelium. The action of harmaline was thus shown to resemble very closely that of quinine.

The pharmacological action of harmine was found to be similar to that of harmaline, but the former alkaloid is only about half as toxic.

Podophyllum Emodi from India

The question of the possibility of employing the Indian species of Podophyllum (*P. Emodi*, Wall.) as a substitute for the American *P. peltatum*, Linn., as a source of medicinal podophyllum, has for many years received the attention of the Imperial Institute. An account of the results of an investigation of the rhizome (underground stem) of *P. Emodi*, carried out at the Imperial Institute, was published in the *Journ. Chem. Soc.* (1898, **73**, 209; reprinted in *Technical Reports and Scientific Papers of the Imperial Institute*, 1903, Part II, p. 1). It was then shown that this species contains more resin than the American plant, and therapeutic trials conducted by Drs. Mackenzie and Dixon with material supplied by the Imperial Institute indicated that the resin from the Indian drug may be substituted for that from *P. peltatum* (*Edinburgh Med. Journ.*, Nov. 1898; reprinted in *Tech. Reps. and Sci. Papers of the Imperial Institute*, 1903, Part II, p. 19).

These results have been confirmed by Mr. J. C. Umney (see *Chem. and Drugg.*, 1911, **79**, 205) and other workers, with the result that the Indian rhizome, which was included in the Indian and Colonial Addendum to the British Pharmacopœia of 1898, has been included in the new British Pharmacopœia (of 1914), so that it can now be employed in official preparations in this country.

All the work hitherto done on the Indian rhizome has been concerned with the wild plant, and it is of interest to record the results of examination of two samples of rhizomes from cultivated plants, which have been examined at the Institute recently. The results of examination of a recent sample of the wild rhizomes are also given.

Cultivated Rhizomes.—These samples were stated to represent the rhizomes and rootlets of plants about seven years old growing in a nursery in Malkandi Forest, Hazara Division. The plants, at the time of gathering the rhizomes, were apparently about half the full size. Sample No. 1 was collected in the late autumn of 1909, and No. 2 in April 1910.

No. 1.—This consisted mainly of thin rootlets about

$\frac{1}{10}$ in. thick, and from 1 to 3 in. long. A few pieces of stem were present, with some dust and dirt.

No. 2.—This resembled No. 1, but consisted of thinner and smaller rootlets.

The samples were examined chemically by the methods described in the paper already referred to, with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*
Moisture	10·2	10·8
Total resin:		
Expressed on material as received	11·1	11·7
Expressed on material dried at 100° C.	12·3	13·2
Podophyllotoxin:		
Expressed on material as received	4·7	3·1
Expressed on material dried at 100° C.	5·2	3·5

Wild Rhizomes.—This sample was forwarded to the Imperial Institute by the Deputy Conservator of Forests, Hazara Division, North West Frontier Province.

It consisted of 11½ lb. of rhizomes and 16½ lb. of broken rootlets. The rhizomes and broken rootlets were separated and examined chemically with the following results:

	Rhizomes. *Per cent.*	Broken rootlets. *Per cent.*
Moisture	9·2	9·9
Total resin:		
Expressed on material as received	15·0	12·7
Expressed on material dried at 100° C.	16·4	14·2

For the purpose of estimating the amount of podophyllotoxin present, the rhizomes and rootlets were mixed in the proportion 11½ : 16½, in order to represent the composition of the original sample. The mixture was found to contain:

Podophyllotoxin:
Expressed on material as received . 2·5 per cent. (approx.)

The results of examination of these three samples are similar on the whole to those obtained with a series of five samples of *P. Emodi* rhizomes from India examined at the Imperial Institute in 1898 (see *Techn. Reps. and Sci. Papers of the Imperial Institute*, 1903, Part ii. p. 1), which contained from 9 to 11·1 per cent. of resin and from 2·8 to 5·3 per cent. of podophyllotoxin, which is one of the chief therapeutically active constituents of the drug.

It will be seen that the samples now reported on contain a high percentage of "total resin" (podophyllin), the form in which the drug is usually employed in medicine: this is especially the case with the wild sample. On the other hand the wild rhizomes are noticeably lower in podophyllotoxin than the cultivated ones.

Croton Elliottianus Seeds from the East Africa Protectorate

In 1906 a small sample of the seeds of *Croton Elliottianus*, Baill., a Euphorbiaceous tree 30 to 50 ft. high, was forwarded to the Imperial Institute by the Director of Agriculture in the East Africa Protectorate. The results of the examination showed that the seeds contained 27·7 per cent. of a yellowish oil, which differed from ordinary croton oil, derived from *C. Tiglium*, in its constants and in the fact that it did not appear to possess vesicating properties (see this Bulletin, 1907, **5**, 237). It was thought, however, that it would be of interest to ascertain whether the oil of *C. Elliottianus* exerts any physiological action similar to that of ordinary croton oil, and a further supply of the seeds was accordingly obtained for this purpose. Dr. J. T. Cash of Aberdeen University kindly undertook to investigate the physiological action of the seeds and oil, and a further chemical examination of the oil was made at the Imperial Institute.

The second sample weighed about 8 lb. and consisted of brownish seeds somewhat resembling castor seed in shape but having rough shells. The kernel was buff-coloured and was covered with a whitish papery skin.

The seeds consisted of 60 per cent. of kernel and 40 per cent. of shell. The kernels were found to contain 57·4 per cent. of oil, corresponding to approximately 34 per cent. in the entire seeds, which is a higher yield than was obtained from the first sample.

The oil was dark yellow, almost tasteless, but possessed a faint turpentine-like odour. Its constants are given in the following table, together with those of the oil from the first sample of seeds, and the oil of *C. Tiglium*:

	Oil of *C. Elliottianus.* First sample.	Oil of *C. Elliottianus.* Second sample.	Oil of *C. Tiglium.*
Specific gravity at 15° C.	0·9266	0·927	0·9428
Acid value [1]	4·2	3·6	—
Saponification value [1]	201·5	191·6	210 to 215
Iodine value . *per cent.*	138·5	147·0	101·7 to 102
Titer test [2]	13·7° to 13·8° C.	about 14° C.	—
Hehner value [3]	94·0	94·8	88·9 to 89·1

[1] *Milligrams of potash for 1 gram of oil.* [2] *Solidifying point of fatty acids.*
[3] *Percentage of insoluble fatty acids and unsaponifiable matter.*

The mixed fatty acids of the oil of *C. Elliottianus* were separated and found to consist approximately of:

Saturated acids:	Principally palmitic acid	10 per cent.
Unsaturated acids:	Linoleic acid	80 " "
" "	Oleic acid	10 " "

The oil therefore consists principally of the glycerides of unsaturated fatty acids. Evidence was also obtained of the presence of a small quantity of hydroxylated fatty acids, but these could not be isolated.

Search was also made for the presence in the oil of resinous constituents, similar to those occurring in *C. Tiglium* oil and to which the vesicating action of the latter oil is due. The experiments, however, gave negative results.

Physiological Examination

The physiological action of the seeds and oil has been carefully investigated by Dr. J. T. Cash and Mr. W. J. Dilling, and their results are given in a paper published in *The Journal of Pharmacology and Experimental Therapeutics* (1914, **6**, 235). It was found that towards man the seed of *C. Elliottianus* is laxative when taken in small doses (0·1 to 0·2 gram), but rapidly purgative (bordering on drastic) in larger amount (0·4 gram). The oil exerts a similar action, but it is less irritant than the seeds and its action is much more uniform. The authors express the opinion that "the relatively non-irritant action of *C. Elliottianus* oil, its certain effect, whether as a laxative in 8 to 10 hours or in larger dose as a speedy purgative, its high potency in relationship to the small bulk, indicate it as a body which would be of considerable value as an addition to purgative remedies, for some of the more drastic and irritant of which it would prove a safe and effective substitute."

OLEO-RESINS

The three products now dealt with all belong to the class of oleo-resins, which are used as substitutes for "balsam of copaiba" and sometimes as adulterants of this product.

Only one of them, the oleo-resin of *Hardwickia pinnata*, has been submitted to a clinical trial in the course of the work now dealt with, and it is possible that that material as well as the oleo-resin of *Daniella thurifera* would repay further clinical investigation.

OLEO-RESIN OF *HARDWICKIA PINNATA* FROM INDIA

The so-called "balsam" of *Hardwickia pinnata*, an oleo-resin obtained by making a deep incision in the trunk of the tree, is said to have proved an efficient substitute for balsam of copaiba in India. It has been examined chemically by a number of investigators, among whom may be mentioned Schimmel & Co. (*Semi-Ann. Rep.*, April 1905, p. 85, and April 1907, p. 109); Weigel (*Pharm. Centr.*, 1906, **47**, 773); and Hooper (*Pharm. Journ.*, 1907, **78**, 4); while Parry (*Chem. and Drugg.*, 1907, **71**, 518) points out that it might be used as a possible adulterant of copaiba, although, as Weigel observes (*Chem. and Drugg.*, 1907, **71**, 618), its detection is rendered easy by its colour.

A sample of the oleo-resin was received for examination at the Imperial Institute from India in February 1913. It consisted of a clear, viscous material, appearing greenish-yellow by transmitted light and deep claret colour by reflected light. On steam-distillation it yielded 32 to 33 per cent. of a mobile yellowish oil, possessing an odour resembling that of copaiba oil. The oil furnished the following results on examination:

Boiling point	238° to 250° C.
Specific gravity at $\frac{15{\cdot}5^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$	0·909
Refractive index at 28° C.	1·497
Optical rotation in 100 mm. tube at 28·5° C.	– 6° 50′
Acid value [1]	0·9
Saponification value [1]	5·2

[1] *Milligrams of potash for 1 gram of oil.*

On suitable treatment the oil gave a blue crystalline nitrosite, apparently identical with or very similar to caryophyllene nitrosite.

The resin left after the removal of the oil by steam-distillation was a hard brittle substance of very dark colour. It furnished the following constants on examination:

Moisture	*per cent.*	1·2
Ash	*per cent.*	0·14
Acid value [1]		158·5
Saponification value [1]		199·7
Melting point		63° to 64° C. (softens at about 58° C.)

[1] *Milligrams of potash for* 1 *gram of resin.*

The resin yielded with turpentine oil an inferior, very slow-drying varnish, and as a varnish material for industrial purposes it could only be used as a substitute for low-grade colophony.

In view of the statement that the oleo-resin of *H. pinnata* is an efficient substitute for balsam of copaiba, therapeutic trials of the material have been carried out at a Military Hospital in London at the request of the Imperial Institute. The hospital authorities reported that the oleo-resin was tested on a number of cases of sub-acute gonorrhœa in doses similar to those employed in the administration of balsam of copaiba. No disturbance of the stomach followed its use, but therapeutically no particular benefit resulted.

Oleo-resin of *Dipterocarpus crinitus* ("Kruing Sap") from the Federated Malay States

A sample of the oleo-resin or so-called "wood-oil" of *Dipterocarpus crinitus*, which was stated to consist of the "sap" of the Kruing tree, which grows abundantly in Selangor, was received from the Federated Malay States in September 1910.

The sample consisted of an opaque, greyish-white, very viscous liquid, possessing an aromatic but slightly sour and unpleasant odour.

On steam distillation the wood-oil yielded 19·5 per cent. of a pale yellow volatile oil, which gradually darkened

This oil, which had a slight, but not unpleasant odour, was found to have the following constants :

Optical rotation	$-43° 48'$
Specific gravity at $\frac{15° C.}{15° C.}$	0·936
Refractive index	1·503

The oil had the characters of the volatile oil of "gurjun balsam," and gave similar colour reactions with chemical reagents.

The residue from the steam distillation amounted to 58 per cent. of the original material, and consisted of a brownish-white resin with a very slight odour. It was examined with the following results:

Moisture	*per cent.*	12·2
Ash	*per cent.*	0·2
Saponification number [1]		88
Acid number [1]		36
Melting point		84° C.

[1] *Milligrams of potash per gram of resin.*

The resin was partly soluble in alcohol or ether, and in mixtures of alcohol and ether, or of benzene and alcohol. It was completely dissolved by chloroform, benzene, or turpentine oil, and by mixtures of turpentine oil and alcohol or of turpentine oil and benzene.

The resin yielded a varnish of inferior quality and poor lustre.

This wood-oil in certain respects resembled "gurjun balsam," which is generally stated to be obtained from *D. turbinatus* and possibly other species of Dipterocarpus. Gurjun balsam has been imported to Europe at various times as a substitute for and adulterant of balsam of copaiba ; when of good quality it is a clear, dark brown liquid, and yields about 54 per cent. of volatile oil.

Although this wood-oil from the Kruing tree yields a volatile oil which has the character of the oil of gurjun balsam, it apparently contains a much smaller quantity, and therefore could not be used as a substitute for the latter. It is, of course, possible that the small yield of oil from the present sample may be the result of exposure of the product to the air in open vessels so that

part of the oil has been lost; but in any case it is scarcely worth while to consider the question of using the material in medicine in place of gurjun balsam, as the demand for the latter is small and uncertain.

Oleo-resin of *Daniella thurifera* from the Gold Coast and Nigeria

Daniella thurifera, Oliv., or as it should be more correctly termed, in the light of recent researches, *Paradaniella Oliveri*, Rolfe (see *Kew Bulletin*, 1912, p. 96), is a tall forest tree, characteristic of dry, open savannas, and widely diffused throughout western tropical Africa. The oleo-resin (also wrongly called wood-oil or balsam) which exudes from the trunks was at one time exported from West Africa under the name "Illurin balsam," to be used, it is stated, in adulterating balsam of copaiba (see, for example, Umney and Bennett, *Chem. and Drugg.*, March 16, 1901). The balsam on exposure to the air for some time hardens; the resin so produced, which is sometimes wrongly spoken of as a copal, has already been reported on by the Imperial Institute (see this Bulletin, 1908, **6**, 250, and *Selected Reports from the Sci. and Tech. Dept., Imp. Inst.*, Part II., *Gums and Resins* [Cd. 4971], 1909, p. 177). Samples of the oleo-resin from the Gold Coast and Nigeria have also been examined at the Imperial Institute, and these are dealt with below.

No. 1. Sample from the Gold Coast.—This consisted of two bottles of oleo-resin, one containing a pale yellow liquid with large oily globules, and the other a pale yellow liquid containing a large amount of a greyish, semi-solid substance. The contents of the two bottles were well mixed before examination. The sample had a characteristic resinous odour.

No. 2. Sample from Nigeria.—This was a viscous, opaque, dark brown liquid, with a rather unpleasant, resinous odour.

The samples were steam-distilled; No. 1 yielded 33·0 per cent. of volatile oil and No. 2 35·0 per cent. The oil in each case was mobile, pale yellow with a faint, aromatic,

pleasant odour. They were examined with the following results:

	No. 1.	No. 2.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·927	0·923
Optical rotation in 100 mm. tube	+ 9° 37′ (at 24° C.)	+ 19° 5′ (at 20° C.)
Refractive index	1·509 (at 20° C.)	1·506 (at 24° C.)
Boiling point	253° to 271° C.	—

The oleo-resin has also been examined by Lenz (*Berichte*, 1914, **47**, 1989), who obtained, on steam-distillation, a yield of 23 per cent. of volatile oil, which was found to contain a considerable proportion of cadinene.

The residual resin after steam-distillation in the case of No. 1 was of yellow colour, with a very slight odour, brittle, and gave a clear transparent, vitreous fracture. That obtained from sample No. 2 was brown, with an unpleasant, slightly aromatic odour. The resins were analysed with the following results:

		No. 1.	No. 2.
Moisture	*per cent.*	2·3	7·6
Ash	*per cent.*	0·3	0·2
Acid value [1]		154	68·0
Saponification value [1]		195	202·0
Melting point		61° C.	60° C.

[1] *Milligrams of potash for* 1 *gram of resin.*

The solubilities of the resins were determined with the following results:

	No. 1.	No. 2.
Alcohol	Partly soluble	Partly soluble
Ether	,, ,,	,, ,,
Alcohol and ether	,, ,,	,, ,,
Chloroform	Completely soluble	Nearly completely soluble
Benzene	,, ,,	,, ,, ,,
Alcohol and benzene	Nearly completely soluble	Completely soluble
Turpentine oil	Completely soluble	Partly soluble
Alcohol and turpentine oil	,, ,,	Completely soluble
Turpentine oil and benzene	,, ,,	Nearly completely soluble

Therapeutic trials with the oleo-resin of *D. thurifera* have not yet been carried out.

NATIVE AFRICAN DRUGS

Sarcocephalus esculentus Roots ("Egbesi") from Sierra Leone

A sample of the roots of *Sarcocephalus esculentus*, Afz. (Nat. Ord. Rubiaceæ), known by the native name "Egbesi," was included in a collection of native drugs from Sierra Leone, which was forwarded to the Imperial Institute in August 1905.

The bark of the stem or branches of this plant was at one time used to a small extent in medicine, especially in France, where it was known as "African Cinchona." It was examined by three French chemists, who stated that it contained a crystalline alkaloid which was named "doundakine." Later Heckel and Schlagdenhauffen asserted that the bark contains no crystalline alkaloid but that its activity is due to a yellow resin, and that it contains, in addition to other yellow substances, an acid, glucose, and tannin (*Pharmaceutical Journal*, 1885, July 11th, p. 50). These authors also stated that as a substitute for cinchona this bark takes only a secondary place, and that there is no justification in its therapeutic action for the name "African Cinchona."

It was stated in the letters which accompanied the specimens, that the "Egbesi" roots exert a tonic, laxative, and antiperiodic action.

In view of the uncertainty regarding the constituents and medicinal value of *S. esculentus* it was considered desirable to examine the roots in order to ascertain whether they contain a crystalline principle possessing a physiological action. No such substance could be obtained, and, beyond ordinary constituents such as fat, glucose, etc., only a resin was isolated. The latter could be separated into two portions (one soluble in sodium carbonate solution and the other soluble in sodium hydroxide), both of which have been examined and found to possess no marked physiological action.

In the light of these results the "Egbesi" roots do not appear to be of any importance for European medicine.

Bark of the Fai Bean Tree (*Pentaclethra macrophylla*) from Sierra Leone

A specimen of the bark of *Pentaclethra macrophylla*, Benth. (Nat. Ord. Leguminosæ), was forwarded for examination to the Imperial Institute from Sierra Leone in February 1908. It was stated that the bark is used by the natives of Sierra Leone both as an anthelmintic and as a fish poison.

The sample consisted of pieces of slightly curved bark, of various lengths, rough externally and smooth internally. The colour was dull reddish-brown. The bark as received was covered with mould, and it was therefore dried and cleaned before examination.

The bark was submitted to a systematic chemical examination, but no constituent of an alkaloidal or glucosidal character was found. A crystalline neutral substance was however isolated, but this proved to be physiologically inactive. Three extracts prepared from the bark by various processes were also found to be quite inactive physiologically.

As it has been suggested that various fish poisons owe their activity to the presence of tannin, the amount of this substance present in the bark was determined and found to be 7·1 per cent. in the air-dried material, which contained 11·7 per cent. of moisture.

The results of this examination show that the bark of *P. macrophylla* contains no constituent likely to be useful in European medicine. The properties ascribed to it as a fish poison may perhaps be accounted for by the tannin present.

It is of interest to note in this connection that the poisonous alkaloid paucine was isolated from the seeds of this tree by Merck in 1894.

"Ebonka" Leaves from Sierra Leone

Specimens of these leaves were received from Sierra Leone in 1907. The plant, which was believed to be *Paullinia pinnata*, Linn. (*Serjania curassavica*, Radlk.) (Nat. Ord. Sapindaceæ), was stated to be used medicinally by the natives for stomachic troubles.

The samples consisted of the leaves of the plant with a few pieces of stem.

The leaves were submitted at the Imperial Institute to a preliminary examination, which did not indicate that they contained any active principle. A mere trace of alkaloid appeared to be present, but not sufficient to exert any medicinal action.

Physiological trials were made by Professor A. R. Cushny, F.R.S., of University College, London, with alcoholic and aqueous extracts of the leaves prepared at the Imperial Institute, but no symptoms whatever were produced in mammals by the injection of the preparations. In one case a cat received a hypodermic injection of aqueous extract equivalent to 33 grams of leaves, and in another case a quantity of alcoholic extract equivalent to 77 grams of the leaves was injected, but in neither case was there evidence of any physiological effect.

"Anet" Leaves from Sierra Leone

These leaves were also received in 1907. The plant was believed to be *Tetracera obtusata*, Planch. (Nat. Ord. Dilleniaceæ), and it was stated that the leaves are used by the natives, either powdered or as a decoction, for the treatment of coughs, and also for preparing a medicinal bath.

The samples consisted of dark brown dried leaves, of varying size, but averaging about 2¼ in. in length and 1¼ in. in breadth. The leaves were submitted to a chemical examination at the Imperial Institute, but no active principle could be isolated. Alkaloids were either absent or present only in very minute traces, insufficient to exert any medicinal action.

Extracts of the leaves were made at the Imperial Institute and submitted to Professor Cushny for physiological trials, but the only definite effects observed were certain symptoms probably due to small amounts of saponin.

"Tatuookroo" Leaves from Sierra Leone

These were received along with the preceding two samples. The plant, which was believed to be a species

of *Cnestis* (Nat. Ord. Connaraceæ), was stated to be used by the natives for preparing medicinal baths.

The leaves were submitted to a careful examination, which, however, has given negative results. No active principle could be detected, and the only constituents isolated were tannin and gum.

BARK OF *KHAYA SENEGALENSIS* FROM THE NORTHERN PROVINCES, NIGERIA

This sample of the bark of *Khaya senegalensis*, A. Juss. (Nat. Ord. Meliaceæ), was received at the Imperial Institute from the Forestry Officer, Northern Nigeria, in April 1906.

The bark is stated to be largely used as a stomachic by natives in Northern Nigeria.

The sample consisted of large pieces of the bark, about ½ in. in thickness, which were brownish-red and possessed a bitter taste.

The material was submitted to a preliminary examination with the following results:

No evidence could be obtained of the presence of alkaloids in the bark. Aqueous and alcoholic extracts deposited a large quantity of an amorphous red body of phlobaphenic character and devoid of taste. There was also found in the bark a quantity of tannin-like substance, of brownish-red colour, which was readily soluble in hot water, and possessed the same bitter taste as the bark.

The bark contained 10·2 per cent. of tannin.

No indications were obtained of the presence of a glucoside nor of the occurrence of any resinous or crystalline neutral constituents.

The bark does not seem to contain anything likely to be of use in European medicine.

FRUITS OF *TETRAPLEURA THONINGII* FROM NIGERIA

A small consignment of the fruits of *Tetrapleura Thoningii*, Benth. (Nat. Ord. Leguminosæ) was forwarded for examination to the Imperial Institute by the Government Chemist at Lagos in February 1907.

The pods were dark brown, about 8 in. long, and were furnished with four longitudinal ridges, two of which were

hard and woody, whilst the other two were filled with soft sugary pulp. The pods contained small, very hard, black seeds, which were bright green internally. Neither the pods nor the seeds contain cyanogenetic glucosides or alkaloids. The soft sugary pulp from the pods contains sugars, tannin, and a small quantity of "saponin." It was not found possible to purify the saponin, but it is to this constituent that the detergent action of the fruits, noted in works of reference, is probably due.

"Olsogonoi" or "Muziga" Bark (*Warburgia ugandensis*, Sprague) from the East Africa Protectorate

A sample of this bark, which was stated to be used by the natives as a purgative, was received in August 1907.

By means of botanical specimens sent subsequently to Kew, the plant from which the bark is derived has been identified as *Warburgia ugandensis*, Sprague (Nat. Ord. Canellaceæ).

About 26 lb. of bark in pieces up to 3 ft. long by 4 to 5 in. wide and to ½ in. thick were received. The outer part of the bark was very rough and dark brown, whereas the inner part was smooth and whitish. The inner bark had a pungent, ginger-like taste.

Chemical examination has shown that the bark contains tannin and about 3 per cent. of mannitol. The pungent taste is due to amorphous resinous substances. No well-defined crystalline substance could be isolated. The bark was free from alkaloids.

The medicinal action of this bark cannot be traced to any definite constituents. It is, however, possible that the activity is due to the resinous substances, but physiological experiments would be necessary to decide this point.

Securidaca longipedunculata from Mozambique

S. longipedunculata, Fres. (Nat. Ord. Polygalaceæ) is a much-branched shrub, reaching 8 to 10 ft. in height, and widely distributed throughout tropical Africa. The plant yields the Buaze fibre of Central Africa, a specimen of which from Nyasaland was examined at the Imperial Institute some years ago (this Bulletin, 1908, **6**, 19). Thoms states (*Der*

Pflanzer, 1913, **9**, 143) that the natives of West Usumbara, German East Africa, employ an infusion of the leaves as a remedy for certain venereal diseases; in other parts the bark is used as a stomachic. In Sierra Leone and Zambezia, he states, the leaves are employed as a remedy for snake bites, and the bark of the roots as soap.

In 1909 a specimen of the roots of the shrub was received from Mozambique, where the plant is known as "M'vara-vara." The roots were woody and yellow, from ⅛ in. to 1 in. in diameter and covered with thick smooth bark. They smelt strongly of oil of wintergreen (methyl salicylate), and had a taste at first pleasant and sweetish but afterwards unpleasant and numbing to the tongue. The powdered root produced a froth when shaken with water, and caused violent sneezing when inhaled.

Chemical examination showed the roots to contain about 0·1 per cent. of methyl salicylate and about 4 per cent. of a substance of the "saponin" class. The latter constituent causes the frothing when the powdered root is shaken with water. Thoms (*loc. cit.*) also demonstrated the presence of methyl salicylate and a saponin in the roots and further found that no alkaloids were present.

The roots would not be of any value as a source of methyl salicylate, since this compound is present in such small quantity. Owing to the saponin it contains, the material might perhaps be employed as a substitute for quillaia bark, which is used to some extent in pharmacy and also for washing delicate fabrics, but since it contains only about 4 per cent. of saponin as compared with about 9 per cent. in quillaia bark it seems unlikely that it could compete successfully with the latter. Commercial experts, to whom a sample of the root was submitted, reported that it was not satisfactory as a source of saponin for their purposes, and that its properties were by no means equivalent to those of quillaia bark.

"Gusangus" Roots from Somaliland

A sample of the roots of the "Gusangus" plant, which are stated to be used by the Somalis for washing in place of soap, was forwarded to the Imperial Institute by

His Majesty's Commissioner in Somaliland in September 1905.

The sample consisted of about ½ lb. of very light fibrous roots, pale brown in colour and of irregular shape.

The results of the chemical examination of the roots showed that they contain a very small quantity of a substance allied to the saponin of quillaia bark, which is used for the similar purpose of producing a lather or foam.

The roots would have no commercial value in this country.

Seeds of *Brehmia spinosa* from Seychelles

A sample of the seeds of this tree was received from Seychelles in October 1907.

Brehmia spinosa, Harv. (= *Strychnos spinosa*, Lam.), is a small tree growing wild in Seychelles, where it is known as "Calebassier" (Calabash). As the tree is allied to the Strychnos genus it was suggested that the seeds should be examined in order to determine whether they contained strychnine.

The sample received at the Imperial Institute consisted of three large spherical fruits and about thirty seeds.

The results of the examination of the seeds show that they do not contain strychnine or any other alkaloid. Fluckiger had already shown that the seeds of *Strychnos spinosa* are free from strychnine and brucine, and according to this author they are not poisonous (*Arch. Pharm.* 1892, **230**, 343).

POISONOUS PLANTS

Much attention has been devoted at the Imperial Institute to the investigation of plants poisonous, or reputed to be poisonous, to man and live stock. Of such investigations, the results of which have been published already in this Bulletin, reference may be made to the work on cyanogenesis in plants, that is the production of prussic acid (1903, **1**, 15, 112; 1905, **3**, 373; 1906, **4**, 334; 1912, **10**, 653); the investigation of *Senecio latifolius*, the cause of Molteno disease of cattle in South Africa (1911, **9**, 346); and of the cause of the irritant action of the satinwoods (1909, **7**, 93; 1911, **9**, 351). An account of the results of examination of

a number of other poisonous plants received at the Imperial Institute in recent years is given below.

Acokanthera venenata from the Transvaal

The attention of the Imperial Institute was first directed to this poisonous plant in 1906 by the Acting Director of Agriculture in the Transvaal, who forwarded a single small specimen of the root for identification, stating that it was suspected that this material had been used in a case of criminal poisoning among natives near Johannesburg. The root was identified at the Royal Botanic Gardens, Kew, as probably that of *Acokanthera venenata*, G. Don (Nat. Ord. Apocynaceæ). In reporting this identification to the Director of Agriculture at Pretoria, the Imperial Institute submitted a short statement giving the information available regarding the constituents of other species of Acokanthera, and pointed out that no detailed chemical examination of *A. venenata* had been made, though the plant was well known to be poisonous.

A small supply of leaves and twigs of the plant was subsequently received from the Director of Agriculture at Pretoria in June 1909. In the letter accompanying the material it was stated that in view of two or three cases of criminal and accidental poisonings having been traced to the use of the bark of this shrub it was very desirable that it should be examined chemically. This sample proved too small for detailed examination, and in December of the same year a further supply was asked for, which was received from the Director of Agriculture in April 1910.

This last supply of material enabled the preliminary chemical and physiological investigation of the plant to be completed, and the results of this work are summarised in the present report.

Previous Work on Acokanthera Species.—The Acokanthera species have long been known as poisonous plants, and they yield a well-known group of arrow poisons. The species best known in this way are *A. Ouabaio*, Cath., *A. Deflersii*, Schw., *A. Schimperi*, Oliv., and *A. abyssinica*, K. Schum. From these species, or from arrow poisons prepared from them, various investigators have

isolated two poisonous constituents, both of which are glucosides, viz.:

1. A crystalline glucoside, called ouabain, or acokantherin.

2. An amorphous glucoside, variously known as abyssinin, amorphous acokantherin, amorphous ouabain, or acokanthin.

A detailed account of these previous investigations need not be given here. They are described by Fraser and Tillie in the *Pharmaceutical Journal* for 1895, p. 76, and by Lewin in the *Berliner Klinische Wochenschrift*, 1906, p. 1583. A summary of information regarding species of *Acokanthera*, especially in relation to their use as arrow poisons, is given by Perrot and Vogt in *Poisons de Flèches et Poisons d'Épreuve* (Paris: Vigot Frères, 1913).

As regards *Acokanthera venenata*, Lewin examined a small quantity of the twigs of this species grown in Italy (*Arch. für Path. Anat.*, 1893, **134**, 231), and isolated an amorphous glucoside, which, though toxic, did not exhibit the chemical and physiological properties of amorphous acokantherin. Another contribution to the subject was made by Krause, who stated (*Tropenpflanzer*, 1909, **13**, 134) that *A. venenata* contained acokantherin and abyssinin, but gave no further details of his work.

Juritz has paid particular attention to the question of poisoning by *A. venenata* in South Africa, and has suggested certain chemical tests for identifying the poison (see *Rep. Senior Analyst, Cape of Good Hope*, 1902, p. 66). Further accounts of his work are given in *Rep. Senior Analyst, Cape of Good Hope*, 1903, p. 60, *Trans. S. A. Phil. Soc.* (1905, **16** [2], 123), and *S. A. Journ. Sci.* (1915, **11**, 128).

Chemical Examination of Acokanthera venenata

As all the species of *Acokanthera* hitherto examined have proved to contain either crystalline or amorphous ouabain (acokantherin) or both of these substances, it seemed reasonable to suppose that *A. venenata* would also prove to contain one or both of these products, especially as the symptoms of poisoning produced by it, so far as they had been observed, were quite similar to those

recorded for the other species. The plant was therefore examined in the first instance by the methods used by previous workers. These may be described briefly as more or less complicated processes for the fractionation of an extract prepared by exhaustion of the plant with alcohol. Of all the methods tried, that used by Faust in his examination of *Acokanthera abyssinica* (*Arch. exp. Path. und Pharm.* (1902, **48**, 272 ; 1903, **49**, 446) proved most convenient, and was finally used for working up the bulk of the material supplied. The method and the details of its application to *Acokanthera venenata* need not be described, but the results may be summarised as follows : No alkaloid was detected in the plant, and no trace of any glucoside yielding prussic acid, such as has been found in certain other poisonous plants examined at the Imperial Institute, could be found. The plant, however, contains a considerable quantity of oxalic acid, and in addition an intensely bitter, amorphous product was isolated, which proved to be highly poisonous. All the other substances obtained were amorphous, and appeared to be physiologically inert.

As the quantity of the intensely bitter and poisonous product obtained was very small it could not be fractionated with a view to the possible isolation of crystalline acokantherin. It is therefore impossible to say whether the amorphous product is a single substance or a mixture. It possesses all the characters of crude acokantherin as described by Faust, and is probably identical with this substance or very closely related to it. This conclusion is amply confirmed by the results of its physiological examination recorded below.

Physiological Action of the Bitter Substance

The investigation of the physiological action of this material was kindly undertaken for the Imperial Institute by Dr. J. H. Burn of the Wellcome Physiological Research Laboratories, who has supplied the following report on his work. As Dr. Burn's results are of great scientific and practical interest they are given in detail.

The examination of the action of a solution of the bitter substance corresponding to a 1 per cent. infusion of the

plant in water shows that it contains principles extremely like those occurring in digitalis (foxglove) leaves; this, of course, was to be expected from the known properties of the allied species *Acokanthera Ouabaio.*

Observations on the Intact Animal

I. *Frog.*—When the minimal lethal dose (about 0·5 mm. of the bitter substance for a 25-gram frog) is injected into the ventral lymph sac, after about an hour all reflexes diminish, and in three hours the frog is dead. The ventricle is then found to be tightly systolic.

The preparation used to determine the lethal dose contained one part of the bitter substance in 10 cc. of solution. The doses are expressed in terms of the bitter substance.

Weight of frog. *grams.*	Dose. *mgm.*	Result.
24	1	Died in 3 hours
24	1	" 3 "
21	0·8	" 2 "
21	0·8	" 2 "
20	0·6	" 2 "
20	0·6	" 2 "
24	0·5	" 3 "
24	0·5	" 3 "
22	0·4	Lived
22	0·4	"
22	0·3	"
22	0·3	"

That is to say the minimal lethal dose is 0·5 mgm. of the bitter substance for a 25-gram frog. As the solution contains one part of bitter substance in 10 cc., and each cc. of the solution represents 100 grams of the plant, then 0·5 mgm. of the bitter substance corresponds to 0·5 gram of the plant.

An infusion of digitalis leaves prepared by heating 2 grams of leaves with 30 cc. of saline solution on the water bath for half an hour in a flask with a reflux condenser gave a minimal lethal dose corresponding to 0·05 gram of leaves. This was not a particularly active batch of leaves. It would, therefore, appear that, in so far as the methods of extraction are comparable, the *Acokanthera venenata* plant contained one-tenth of the amount of

active principles which a moderate sample of digitalis leaves possessed.

II. *Guinea-pig.*—When the minimal lethal dose was injected subcutaneously, after half an hour, the animal began to give sharp convulsive coughs owing to the action of the principle on the respiratory centre. These soon became acute, and the convulsions spread to the whole musculature of the body. Micturition and salivation took place. Death followed quickly, occurring forty minutes after the injection. Post-mortem examination showed fairly normal lungs, with a widely dilated heart. In the case of death from the minimal lethal dose, the cause of death was paralysis of the respiratory centre. Only with much higher doses was the heart found to be tightly systolic.

The minimal lethal dose was 3 mgm. of bitter substance for a 300-gram guinea-pig.

Action on the Heart

The resemblance of the principles of *Acokanthera venenata* to those of digitalis comes out in all its detail when the preparation is examined on the isolated perfused mammalian heart.

Two minutes after perfusion of the solution began, the "therapeutic" stage of the action was clearly seen where the amplitude is increased and the frequency slowed. After seven and a half minutes there was a well-marked period of "Cushny's waves," and after sixteen minutes complete quiescence in systole. During the perfusion the coronary flow gradually diminished to one half its initial rate, and then again increased slightly.

Action on the Blood Pressure

When injected intravenously into a cat, either under ether anæsthesia or after destruction of the brain and subsequent removal of the anæsthetic, the bitter substance is seen to have a marked pressor action. A quantity of solution corresponding to 5 mgm. of the bitter substance was given intravenously to a cat whose brain had been destroyed. After causing a large rise in the blood-pressure, the substance affected the heart so that this became

delirious. This condition passed away in about one minute, and the blood-pressure gradually began to fall. That this rise in blood-pressure is due to a definite vaso-constriction is shown by the fact that the lever attached to an intestinal plethysmograph falls when the blood-pressure rises. In this experiment the cat was under ether anæsthesia.

Such a vaso-constriction might be caused by a stimulus either (*a*) to the sympathetic ganglia, or (*b*) to the nerve-endings of sympathetic nerves in the blood-vessel walls, or (*c*) to the muscles of the blood vessels themselves.

The actual site of the application of the stimulus appears, in fact, to be the muscles of the blood vessels, as the rise can still be elicited after complete paralysis of the vaso-constrictor nerve-endings of the sympathetic system with ergotoxine.

Action on Plain Muscle in General

The action on the blood vessels would seem to be part of a general action on plain muscle. Thus, a dose corresponding to 0·5 mgm. of the bitter substance put into a 50 cc. bath of oxygenated Ringer at 37° produces a large contraction of an isolated uterus of a virgin guinea-pig.

Action on the Kidney

A record of the flow of urine from the ureters into the bladder during the intravenous injection of 5 mgm. of the bitter substance showed that corresponding with the initial rise of pressure the flow decreased, but that soon there was a slight but not very considerable increase in the rate of kidney secretion. This diuretic effect was no doubt considerably masked by the high blood-pressure and the accompanying constriction in the renal arteries.

Summary

The action of *Acokanthera venenata* is therefore in every way like that of digitalis. It has a primary slowing and strengthening effect on the heart which quickly passes into a toxic effect, leaving the heart quiescent in systole. It has a pressor effect when injected intravenously, due to an action on the plain muscle of the arterioles. It appears to

have a contractile effect on all plain muscle. It has also a slight diuretic action.

General Remarks

The chief interest of the results of an investigation of this kind lies primarily in the possibility of using them in the detection of the poison in cases of accidental or criminal poisoning. The results of the chemical examination recorded in the earlier portion of this report show that the poisonous substance is so ill-defined that a chemical examination would be of little value in such cases, and reliance would have to be placed chiefly on observation of the character of the toxic symptoms. From this point of view Dr. Burn's record of the principal physiological effects of the poison are of special interest.

The fact that *Acokanthera venenata* may also be of medicinal value as a substitute for digitalis should not be overlooked, although it is not probable that it will be of practical value in medicine, since it is only one-tenth as active as digitalis (foxglove), and moreover offers no advantages over digitalis, which is obtainable cheaply almost everywhere and is universally recognised as a trustworthy therapeutic agent, when properly collected.

"Cape Slangkop" (*Ornithoglossum glaucum*) from South Africa

The question of the toxic properties of "Cape Slangkop" (*Ornithoglossum glaucum*, Salisb.) has occupied the attention of the Imperial Institute for some years past, and various samples have been furnished by the South African authorities for investigation, the last being submitted in February 1914.

The samples received consisted of moist bulbs, from 1½ to 3 in. in diameter, and reddish-brown throughout. A quantity of the stems and leaves of the plant was also furnished with two of the samples of bulbs.

The bulbs were first cut into thin slices, dried at a low temperature, and then reduced to fine powder by grinding. The ground material had an intensely bitter taste, and the dust when inhaled produced a very unpleasant and irri-

tating effect on the throat. The stems and leaves were devoid of any bitter taste, and the investigation has therefore been restricted mainly to the bulbs.

A preliminary chemical examination of the first sample of bulbs showed that two of the most commonly occurring classes of plant poisons, viz. alkaloids and substances producing prussic acid, were absent. An extract containing the bitter constituent of the bulbs was therefore prepared and submitted to Professor Cushny for trial, in order to determine whether it possessed toxic properties. The results showed that the extract was intensely poisonous to animals, and the chemical evidence suggested that the actual toxic substance was a glucoside or a mixture of glucosides.

The examination of the later samples of bulbs confirmed these results, and the investigation has since been devoted to the work of isolating the bitter toxic constituent in a pure condition. Owing, however, to the presence in the bulbs of sugar and starchy matters, and also possibly to the unstable nature of the bitter substance, the numerous attempts to isolate the latter in a pure state have so far proved unsuccessful.

The results obtained in this investigation may be summarised as follows:

No crystalline substance possessing the bitter taste of the bulbs has been isolated, but a bitter and extremely poisonous constituent, which has not yet been separated in a pure state, is present in the impure amorphous residues obtained on extracting the bulbs with solvents. It is possible that the active substance undergoes decomposition during extraction, and this would account for the difficulty experienced in isolating it, and also for the gradual diminution in bitterness of the residues that was noticed as the experiments proceeded.

The extract containing the bitter substance was found to exert an intensely poisonous action on frogs, rats, and cats, the effect produced being typical of the digitalis group of heart poisons.

The practical outcome of the work is that in South Africa the plant should be proclaimed as dangerous in

grazing lands, and farmers should be urged to exterminate it by uprooting it wherever it occurs on their land. Until it has been exterminated cases of the poisoning of cattle are bound to occur from time to time, and to cope with these it was suggested that the Government Veterinary Officers should be asked to devise an antidote suitable for use by farmers in those parts of South Africa where the plant occurs. Owing to the striking similarity between the physiological action of Slangkop and digitalis (foxglove), it seems likely that antidotes successfully used against digitalis will also prove effective against Slangkop.

Tephrosia Vogelii from Rhodesia

Tephrosia Vogelii, Hook. f. (Nat. Ord. Leguminosæ), is well known as a fish poison, and its constituents and poisonous action have been investigated by several workers. Hanriot, who examined the leaves of the plant obtained from the Comoro Islands, isolated from them three substances: (1) a poisonous principle, tephrosin, a crystalline neutral body melting at 187° C., which is especially active towards fish; (2) a volatile oil, tephrosal; and (3) a yellow substance which was not characterised. Tephrosin is almost insoluble in water, but is soluble to a small extent in boiling water, as is shown by the poisonous properties of the solution.

When a fish is placed in a dilute solution of tephrosin it shows great excitement at first but soon becomes quiet; the fins lose colour and become paralysed, and the fish turns over and eventually dies.

In Hanriot's experiments the fish were immersed in solutions varying in strength from 1 part in 250,000 to 1 in 100,000,000 of water. Concentrations from $\frac{1}{250,000}$ to $\frac{1}{10,000,000}$ had approximately the same activity, the fish turning over in from 5 to 7 minutes and dying in times varying from 15 minutes to about 1 hour. A concentration of $\frac{1}{50,000,000}$ was the minimum strength having fatal results. The figures here quoted only give the concentration of the solution, and not the weight of poison absorbed; for several fish may be poisoned one after the other in the same solution.

All fish are susceptible to the poisonous effects of

tephrosin, but not to the same degree. Of fresh-water fish, the roach is very sensitive to this poison, then come in order the minnow, perch, carp, bream, tench, eel, and lamprey. Salt-water fish are also affected, but not to the same degree.

The action of tephrosin upon certain other animals is much less marked than upon fish; thus, for example, rabbits eat the leaves of the plant with impunity, and dogs have been given as large a dose as 1 gram of tephrosin with their food without effect. Frogs have been unaffected when placed for days in solutions strong enough to kill fish almost immediately, and crustaceans such as crayfish, crabs, lobsters, etc., are only very slightly sensitive to tephrosin.

Experiments were also made by Hanriot to determine the effect of tephrosin on mammals when injected hypodermically. The fatal dose for a rabbit was found to be 0·01 gram per kilogram of body-weight. The symptoms were intoxication, convulsions alternating with paralysis, and death by stoppage of respiration, the heart continuing to beat.

Similar results were obtained with the dog, the fatal dose being also 0·01 gram per kilo weight when injected subcutaneously (see papers by Hanriot in *Comptes Rendues*, 1907, **144**, 150, 498, 651).

In a paper on "Plant Lactones as Fish Poisons," Priess (*Ber. deut. Pharm. Gesell.*, 1911, **21**, 267) confirms the presence of tephrosin in *T. Vogelii*, obtained from Amani, German East Africa.

Specimens of the leaves and seeds of *T. Vogelii* have been received at the Imperial Institute from Rhodesia, where the plant is known as "Ululu" or "Uwa," and these have been examined with the results given in the following pages.

Leaves

The leaves were long and narrow, varying in length from $\frac{7}{8}$ to 3 in. and in breadth from $\frac{3}{8}$ to $\frac{3}{4}$ in., and were generally of a pale yellowish-green colour, being somewhat darker on the under surface. They possessed a distinct and somewhat pungent odour. Some small stems were

present, which were of brownish-yellow colour and were thickly covered with short hairs.

The leaves were first tested by trials with fish, and were found to be physiologically active. They were then submitted to chemical examination, and the three substances recorded by Hanriot were isolated. No other characteristic constituent was observed, and no evidence was obtained of the presence of substances of an alkaloidal or glucosidal nature.

The percentage yields of the three constituents were approximately as follows:

Tephrosin .	0·15	Tephrosal .	0·06	Yellow substance .	0·05

The properties of these substances were found to agree generally with those recorded by Hanriot.

The tephrosin was obtained in small, nearly colourless crystals, melting at 192° C. (uncorr.). It does not contain nitrogen, and does not reduce Fehling's solution even after boiling with dilute hydrochloric acid.

The volatile substance tephrosal, to which the pungent odour of the leaves is due, is, when freshly prepared, a thick, pale yellow liquid, with a rather sharp and penetrating odour.

The yellow substance is a crystalline neutral compound which melts at 228°–229° C. (uncorr.). It contains no nitrogen, and does not reduce Fehling's solution even after boiling with dilute hydrochloric acid.

The results of the examination of *T. Vogelii* leaves from Rhodesia confirm those obtained by Hanriot with supplies of this plant from the Comoro Islands, and by Priess with material from German East Africa (see above), and show that the action of the plant as a fish poison is mainly dependent on the tephrosin it contains.

Seeds

The samples consisted of small flattish kidney-shaped seeds, of a dark chocolate colour and having a prominent white hilum; they were very uniform in size, the average dimensions being about $\frac{1}{4}$ by $\frac{3}{16}$ in.

The seeds yielded 12 per cent. of a fixed oil, which was of thick consistency and brown in colour.

After the fixed oil had been removed, the seeds were examined for substances likely to be physiologically active. An extract was obtained by percolation with chloroform, and this was separated into two portions differing in solubility, which were investigated with the following results:

(*a*) The less soluble portion yielded tephrosin, and a small quantity of the yellow crystalline substance, melting at 228°–229° C. (uncorr.), present in the leaves.

(*b*) The more soluble portion also yielded tephrosin, together with a third substance not met with in the investigation of the leaves of *T. Vogelii.* This substance was colourless, and proved to be free from nitrogen. It had a melting point of 158° C., and was insoluble in water, very slightly soluble in ether, and only slightly soluble in alcohol. From a mixture of acetone and chloroform it crystallised readily in large tabular crystals, containing 22·4 per cent. of chloroform of crystallisation and melting at 109° C.

The percentages of the above-mentioned substances actually separated in the crystalline state from the seeds were as follows:

Tephrosin	0·3
New substance, melting at 158° C.	0·11
Yellow substance, melting at 228°–229° C.	0·008

After the removal of these substances by crystallisation there remained a considerable proportion of uncrystallisable residue, the composition of which it has not so far been possible to determine.

The results of this investigation show that the seeds under report yielded twice as much tephrosin as the leaves examined at the Imperial Institute, and it may be assumed that their activity as a poison would be correspondingly greater than that of the leaves.

Fruit and Leaves of the Afon Tree from Lagos

Extracts of the leaves and fruit of the Afon tree, *Treculia africana*, Dcne. (Nat. Ord. Urticaceæ), were prepared by the

Government Chemist in Lagos and were forwarded for examination to the Imperial Institute in April 1905.

The tree is reputed in Lagos to be poisonous to animals and the Commissioner of Abeokuta had reported that it was impossible to take horses to certain districts in the Colony owing to water-holes and streams being poisoned by the leaves of the Afon tree. On the other hand the Director of Forests and Agriculture attributed the poisonous properties to the fruit of the tree, as also did the Government Chemist. The latter stated that the belief in the poisonous nature of the fruit is very widely spread amongst the natives, although they use the seed when cooked as food.

Four extracts of the leaves and fruit of the tree were forwarded for examination, and the following particulars regarding these were supplied :

1. Aqueous extract of Afon leaves.—"Seventy-seven grams cut up and allowed to soak and rot in water for about eleven days in the cold. Filtered once."

2. Aqueous extract of Afon fruit.—"One half of a fruit was cut up, put into water, and allowed to soak and rot for about eleven days in the cold. The mass was then removed and the liquor pressed once through a filter. This (by popular belief) should be fatal to horses."

3. Alcoholic extract of leaves.—"Seventy-seven grams leaves cut up and soaked in about 90 per cent. methylated spirit about eleven days at ordinary temperature. Two extractions thus, using a fresh lot of spirit for the second. Concentrated extracts by distilling off most of the alcohol."

4. Alcoholic extract of fruit.—"Fruit cut up and soaked eleven days at ordinary temperature. Then two fresh quantities of spirit used for one day each. These latter extracts concentrated slightly by distilling off some of the spirit and adding residues to original extract."

The extracts were tested for the Imperial Institute at the Pharmacological Laboratory of Cambridge University, but none of the preparations was found to be poisonous to animals.

The extracts have also been examined chemically at the Imperial Institute, but no poisonous constituents were found.

SPECIAL ARTICLE

NOTES ON THE LIME AND THE LEMON AS SOURCES OF CITRIC ACID AND ESSENTIAL OILS

By W. R. Dunlop

Scientific Assistant to the Imperial Department of Agriculture for the West Indies

Introductory

During recent years, in tropical agriculture, lime cultivation has been one of the minor booms. Prices have ruled extraordinarily high for the various products of this citrus plant, and at the present time large areas of land are being placed under cultivation not only in the West Indies but also in other parts of the tropics.

Economic Status of the Industry.—In magnitude, in volume of trade, the lime-growing industry at present is very small in comparison with industries like rubber or sugar production. Even the world's trade in citrus products is insignificant in comparison with these. But in two respects, at least, lime cultivation has something in common with those of rubber and sugar. It produces commodities of Imperial origin, important for human consumption and essential for manufacturers in Great Britain. Further resemblance lies in the fact that all these are subject to direct competition. Colonial rubber has to compete with Brazilian; colonial sugar has a rival in beet sugar; colonial lime juice, oils, and fruits have to compete with the products of the Sicilian lemon.

It will be well, however, at the outset to dispel any misapprehensions on this latter point by saying that for the present there are no indications that the supply of lime products will exceed the demand. As a matter of fact lime products, generally speaking, serve industrial purposes different from those of the lemon, but the fact remains that Sicily to a large extent regulates the market price for citric acid, which is the essential constituent of lime juice and of calcium citrate. Sicily, also,

because of her large production, influences the prices for essential oils of the citrus group.

It occurred to the writer, in view of the increasing area under limes and the attention which lime growers give to Sicilian affairs, that it would be interesting to contrast the lemon and the lime as sources of citrus products, to compare their respective yields, and their positions in the world's markets. At the same time it was thought desirable to give in outline the methods practised in cultivating limes in the West Indies for the benefit of intending capitalists, and to indicate how the market opinion of lime products compares with that of lemon products. The lemon is not, like the lime, dealt with from the agricultural standpoint, for the reason that the area under lemons—except perhaps in the United States of America—cannot extend, for the plant requires very special conditions of soil and climate, and the industry in Sicily is fully established. Moreover the lime crop appears to be better suited to tropical conditions than the lemon. As regards exports, then, the future development of the citrus industry in prepared products depends almost entirely upon the extension of lime cultivation, which is especially well adapted to the West Indies and Central America.

Extent of Production of Citrus Products

The commodities dealt with principally in these notes are raw and concentrated lime juice, citrate of lime, and the essential oils. Some idea of the relative importance of lemon and lime products (excluding in the case of lemons the fresh fruit trade) can be obtained from the following figures showing the exports of lime products from the British West Indian Colonies during 1913–14:

	£
Dominica	142,662
Montserrat	5,977
Jamaica (average last four years)	4,179
St. Lucia	3,108
British Guiana	1,530
Total	£157,456

These figures include the fresh limes exported chiefly to New York, worth about £40,000. It may be added that lime products worth some thousands of pounds are also exported from Porto Rico, Mexico, and other foreign countries of Central America.

The value of citrus products prepared from the lemon exported from Sicily in 1908, which may be taken as an average year, amounted to about £840,650. *Bulletin* No. 60, *Bureau of Plant Industry*, *U.S. Dept. Agric.*, gives the following analysis in dollars:

	$
Citrate of lime	2,678,489
Citrus essential oils	1,380,455
Raw juice	121,098
Concentrated juice	23,208
Total	$4,203,650[1]

[1] *Approximately* £840,650.

As a general rule, the value of the fresh lemons exported equals the combined value of the so-called by-products, excluding peel. This shows the magnitude of the citrus trade of Sicily. During 1912–13, the fresh fruit trade increased greatly owing to the failure of the Californian crop, which partly meets the American demand. Hence the amount of by-products that could be made in Sicily was relatively small, and consequently prices ruled high for the West Indian products. During 1912–13 the quantity of citrate of lime produced by Sicily was only 3,445 metric tons and of concentrated juice only 22,042 Imperial gallons—considerably less than the mean annual production or consumption during the last five years.

It will now be more or less evident that Sicily, being the chief source of citrus products, must to a large extent regulate the market. It may be remembered, however, that the total or combined exports of lemons and by-products from Sicily has not increased for years and is not likely to grow appreciably larger. On the other hand the export of lime products has increased rapidly during the past few years and is certain to increase further, thereby strengthening the position of limes on the market.

Composition of the Two Fruits

The commercial yields of acid and oils will be described later. In this section attention will be given to the chemical composition of the fruits.

The *Lancet* for March 28, 1908, published the results of analyses of two samples of limes and lemons which showed the lime in all important respects to be the richer fruit. The report, which was reproduced as a leaflet by the West India Committee, stated that "the lime, although smaller than the lemon, yields, weight for weight, a good deal more juice. Thus the average amount of juice expressed from a lemon was 37·5 per cent. of its weight, whereas the lime gave 59·0 per cent. Moreover the lime gives more citric acid but less sugar." This report included analyses, which showed the citric acid content of the lemon to be 4·57 and that of the lime 5·60 grams.

In order to extend this investigation the writer obtained two commercial samples of limes from different sources, and three commercial samples of lemons from ordinary retail shops in London. The results obtained on examination were as follows:

	Description of fruits.	Number of fruits to 500 grams.	Juice expressed.	Citric acid in juice [1]
			Per cent.	*Grams per 100 c.c.*
A. Limes .	Fully ripe, in fair condition and of good size	$9\frac{1}{2}$	56·8	7·05
B. Limes .	Fully ripe, poor condition, of uneven size	15	47·0	7·74
C. Lemons	Three fully ripe and three slightly green, small	6	28·8	7·56
D. Lemons	Good quality and size . . .	$3\frac{3}{4}$	41·6	6·77
E. Lemons	Good quality and uniform, very small, almost approaching the lime	$7\frac{1}{2}$	40·8	7·4

[1] *Expressed as crystallised citric acid, containing* 1 *molecule of water.*

Taking the average of the figures shown in columns 4 and 5 of above table we get the following:

	Juice expressed. *Per cent.*	Citric acid in juice. *Grams per 100 c.c.*
Limes	51·9	7·40
Lemons	37·1	7·24

These results show, even with limes not of the first grade, that the lime undoubtedly contains a higher per-

centage of juice and of citric acid than the lemon, but the difference is not quite as great as the *Lancet* figures seem to show. Dr. Francis Watts, C.M.G., in the West Indies, during 1905 tested limes and lemons grown in Dominica (see *Annual Report on Botanic Station, Dominica*, 1905-06), and as regards the acid content obtained the following results:

LIMES

	Spineless.	Ordinary.
Percentage of juice	51·3	50·8
Citric acid, grams per 100 c.c.	11·70	11·15
Citric acid, oz. per gallon	15·71	14·18

LEMONS

	Italian.	Villa Franca.
Citric acid, grams per 100 c.c.	11·17	11·37
Citric acid, oz. per gallon	13·28	15·39

These values relatively are more in accord with the writer's figures, though absolutely the acid content is much higher. It is clear that in the case of the relative composition of citrus fruits great care must be exercised to secure examples which are in a comparable condition. There is undoubtedly a loss in citric acid on keeping.

At all events, the writer's figures are of interest as an indication of the composition of limes and lemons actually being sold to the public during the winter months in London.

It would appear that the lemon contains a larger percentage of essential oils than the lime, possibly owing to the thickness of the skin. But the lime is richer in phosphoric acid and possesses special anti-scorbutic properties—both matters of importance from a dietetic point of view.

Method of Cultivating Limes

The cultivation of limes in the West Indies has been fully dealt with in *Pamphlet* No. 72 *of the Imperial Department of Agriculture for the West Indies*, but it will not be out of place to give in these notes an outline of the methods adopted. Moreover, in connection with the preparation of lime products the principles worked upon are the same as for the lemon, so that the information will be of interest to the reader who is unfamiliar with either industry.

Selection of Land.—In considering the cultivation of limes it will be convenient to sketch the establishment and general management of an estate in Dominica or St. Lucia, two of the principal citrus islands of the Lesser Antilles.

Flat or gently undulating lands should be chosen if possible, in a locality which is well sheltered and situated from sea-level up to 800 ft. elevation, and possessing a rainfall varying from 80 to 160 in. per annum. If the rainfall is well distributed, 60 in. may suffice. In the West Indies, where limes thrive best, the average temperature is about 80° F. in the shade.

Preparation of Land and Planting.—If necessary, the land is cleared of forest in the usual way, and after planting the seedlings (generally 15 by 15 ft.) the weeds are kept down by cutlassing around the young plants. Before planting, however, adequate provision has to be made for roads, drainage, and windbreaks. Drainage depends upon local conditions of soil and climate, but often it is not apparent that drainage is necessary until the estate is being worked. Care should be taken to plant the trees in straight lines; otherwise, if drainage operations have to be started, grave damage may be done to the groves. Windbreaks are generally essential from the beginning. There are several trees used as permanent windbreaks, such as Galba (*Calophyllum Calaba*) and Pois-doux (*Inga laurina*); whilst the sugar-cane and Madura (*Glyricidia maculata*) make good temporary shelters.

Nursery Work.—Seedlings for planting out have to be raised in special seed-beds in nurseries. Up to the present most of this work in the West Indies has been undertaken by the local Agricultural Departments, which have supplied the estates with many thousands annually. Now the estates are beginning to raise their own. There are no special difficulties attending this work, provided that a good water supply is secured. Success then depends largely on practical experience.

After-cultivation and Manuring.—Assuming that the estate is now planted up, it remains to consider next what after-cultivation is necessary. The point to remember in this connection is that the root system of the lime tree

is surface feeding. Hence tillage has to be very cautiously performed, and it is generally disadvantageous in the long run to plant catch crops. Very little pruning is required, but attention must be paid to cases of injury by wind and to replacing those trees that die.

As regards manuring, the first essential is to maintain the soil humus. This is done by the careful use of green dressing and by the application of mulch, green manure, and possibly artificial manures. Very little is yet known concerning the manuring of limes. Experiments have recently been started in this direction at Dominica, and in a few years' time we shall be better able to give advice. As a matter of fact, even in a more general way, there is not a great deal known about the requirements of the lime plant. It has been rather neglected, because it was not until quite recently that this plant became prominent as a tropical cultivation. More attention, experimentally, has been given to its products, like the composition of the fruits, lime juice, and oils, than to the plant itself. As already stated, this neglect is being remedied.

Pests and Diseases.—It should be pointed out, however, that a considerable amount of work has been done in connection with the pests and diseases of the lime tree, principally by the entomologists and mycologists of the Imperial Department of Agriculture. The insect pests attacking limes have not as a general rule assumed a serious aspect. For one thing, the moisture conditions generally favour the destruction of parasitic fungi. Fungus troubles have been greater, and the well-known local West Indian root disease occasions considerable loss in some places unless draining, trenching, liming, and the burning of diseased material is rigorously carried out.

Time of Maturity and Yields.—The lime crop takes about five years to come into bearing. Under favourable conditions the trees may yield a few fruits in the third year, but it is nearer eight or ten years before the estate can be regarded as yielding its maximum crop. A lime tree continues to yield for at least forty years after first beginning to bear.

In Dominica and St. Lucia the main crop is gathered

from June or July to November or December. Four or six months is required for the development of the fruit from the flowering stage.

The yield per acre of an established lime plantation varies considerably, but a good average is 150 barrels of fruit. The weight of a barrel (4½ cubic-foot contents) of limes is about 160 lb. Hence an acre of good land may be regarded as yielding 24,000 lb. of fruit.

Harvesting.—The gathering of the crop depends upon the way it is to be disposed of. Fresh limes for export as such are picked from the trees in a green condition; fruit from which manufactured products are to be made are allowed to ripen on the tree and fall to the ground.

Production of Lime Products in the West Indies

Raw Lime Juice.—The greater portion of the crop is disposed of as concentrated and raw lime juice. A barrel of limes gives about 7½ gallons of juice. There is generally a considerable loss owing to the imperfect working of the mill, which may reach 2 gallons of juice per barrel. Fresh lime juice contains 12½ to 14 oz. of citric acid per gallon. In preparing the lime juice the strictest attention must be paid to cleanliness and to proper straining.

Concentrated Lime Juice.—In order to reduce freight charges lime juice is generally concentrated to contain 100 oz. of citric acid per gallon, but the degree varies according to market prices. During the process of concentration there is an unavoidable loss of acid due to burning. In the case of open tayche concentration, such as is generally employed at present, this amounts to over 10 per cent.; but with the steam coil vat the loss is nearer 2 per cent.

Citrate of Lime.—Under certain circumstances, it is found advisable to dispose of the lime juice as calcium citrate or citrate of lime. Its preparation is simple. The raw juice is run into a vat and heated to boiling point, and is then neutralised with pure slaked lime. The disadvantages attendant on making this product on a small scale are the washing and drying arrangements which are necessary.

It is generally accepted that 76 barrels of fruit are required to make 6 cwts. of citrate of lime, or 1 gallon of juice is equivalent to 1·18 lb. of citrate of lime.

Essential Oils.—Before the fruit is crushed with a view to manufacturing the above products it is usually "écuelled" or hand-pressed to extract the essential oil in the skin. The quantity of oil obtained by this method of pressing the fruit over a spiked surface varies with the skill of the worker, but in practice 1¾ to 2 oz. per barrel of fruit may be taken as an average figure, though the yield is often considerably higher.

Distilled oil of limes is an entirely different substance. This oil is distilled from the juice during concentration, and although the yield is higher than in the case of the hand-pressed product, being 4 lb. for every 100 gallons of juice, its market price is much less than that of "hand-pressed" oil.

"Hand-pressed" oil usually fetches from 5*s.* to 6*s.* per lb.; distilled from 1*s.* 2*d.* to 1*s.* 6*d.* per lb.

Fresh Limes.—During the last ten years a very considerable trade in fresh limes has developed between Dominica and New York. Latterly St. Lucia and other West Indian colonies have participated in this trade. Great care must be exercised in the matter of preparing the fruit for export. The green fruit must be kept in a packing house for a few days previous to being shipped in order to allow the fruit to quail—that is, lose excess of moisture in the skins. The fruit must be carefully graded, wrapped in paper, and packed in ventilated barrels. Careful handling in all operations is an essential feature.

Whether, in the future, as the area under limes grows larger, the fresh fruit trade will increase greatly, is difficult to foresee. In the United States the lime appears to be replacing the lemon for certain purposes. In the case of the United Kingdom, the trade has never assumed any great importance for several reasons. In the first place, the voyage to England is nearly twice as long as to New York, which puts difficulties in the way of transporting perishable produce. Secondly, the British taste is conservative. The public is familiar with the lemon, and is

not generally inclined to discard it in favour of the lime, even if this fruit were regularly available. As a matter of fact, the fresh lime can only be available in any quantity during the latter half of the year, whilst the lemon is always to be had. Furthermore, the fresh lime is essentially an article for immediate sale. It does not keep as well as the lemon, and the retail salesmen do not view it with favour from a business point of view. In New York the consumption during the hot months is rapid and continuous; the fruit can therefore be bought with a certainty of profitable sale.

Of course the peculiar feature of the fresh lime trade is its elasticity or accommodating nature. If prices range beyond a certain point it pays to ship; if they do not, the fruit can be held back for manufacturing purposes. The trade with New York is run on this principle, and it is worthy of note that growers are not absolutely dependent on this outlet for their produce.

In the case of the United Kingdom it would seem for the present quite unnecessary to go to any expense with a view to pushing the fresh lime trade, as it is likely that more profit is to be made there out of concentrated juice and the essential oils—two products which do not really now come into direct competition with Sicily because that country produces citrate and essential oils which have special uses.

Nevertheless, if a demand for limes could be created they would both chemically and dietetically withstand competition with the lemon.

The Production of Lemon Products in Sicily

In this section it is not intended to deal with the establishment of lemon groves from an agricultural point of view, but to point out such economic aspects of production as are likely to be of interest and of use to those concerned principally with lime cultivation in the British tropics.

It will be of interest, however, to begin by noting that lemon cultivation in Sicily and other parts of the sub-tropics has characteristic features. Variation in the

physical condition of the soil affects the relative yields of juice and oil, not to mention the period of ripening. In a general way, also, irrigation and protection from frost are necessary for lemon cultivation, which differs from lime growing in these respects. Another matter of interest is that the plants are usually kept in the nurseries until three years old. They are then planted in the groves (generally 15 ft. by 15 ft.) and come into bearing when six years old.

The season of lemon ripening in Sicily varies. It is considered to begin on October 1 and end on September 30 following. Fruit is therefore produced all the year round. The heaviest yields of each locality usually occur during the second, third, or fourth months in the season. The fruit gathered in the first harvest in each section is considered to be inferior in keeping quality.

Yields and Profit.—On this point we may quote the *Perfumery and Essential Oil Record* for August 1914, which contains a translation of an article that appeared during the same year in *Le Journal d'Agriculture Tropicale.* "Working on averages we get the following figures: 1,000 fruits of 100 grams, that is to say 100 kilograms give (after machine peeling to a depth of 2 mm., and thus removing the portion rich in essence) 30 kilograms of peel, from which by sponge or 'écuelle' may be obtained 400 grams of essential oil. This yield varies with locality, care in cultivating, variety, and soil. It may be reckoned, then, that 2,500 fruits give a kilogram of essence, and, accepting the figure recently offered of 275,000 fruits per hectare, a total of 100 to 110 kilograms of essence for this area. From the pulp after expression, one may expect a yield of 45 per cent. of juice or 12,000 kilograms per hectare. This juice contains 5 to 7 per cent. of pure citric acid, which means 720 kilograms. But this is evaporated to a specific gravity of 42° Beaumé, equal to an acidity of 40 to 45 per cent. This liquid, neutralised with chalk, gives a citrate of lime estimating 65 per cent. of citric acid. To sum up, a hectare of lemon trees under favourable conditions of culture can pro-

duce: 100 kilograms of essence at 20 francs, worth 2,000 f.; 700 kilograms of citric acid at 3 f., worth 2,100 f.—in all, let us say, 4,000 f., admitting that the entire production is treated industrially, which is not usual. In any case, allowing an expense roughly estimated at 1,500 f. per hectare, the profit would be from 2,500 to 3,000 f. per hectare" (= about £50 per acre).

Lemon and Lime Yields and Profits Contrasted

The writer has prepared the following table, based on the above figures, to show the relative yield in lemon and lime cultivations:

	Lemons. *lb. per acre.*	Limes. *lb. per acre.*
Yield of fruit	27,460	24,000
Yield of juice	10,560	11,550
Containing		
Citric acid	634	914
Oils	88	$65\begin{cases}19\\46\end{cases}$

These figures indicate that the yield of fruit per acre in the case of lemons is greater than the yield of limes, taking four lemons to the pound; but the yield of juice and citric acid is considerably less. The amount of oils yielded, however, is greater in the case of the lemon.

It seems that the figure "275,000 lemons per hectare" given in the reference quoted above can be accepted as being representative of the average lemon grove. The English equivalent for the above figure is 110,000 fruits per acre, and if there are 190 tons per acre, this gives a yield per tree of about 580 lemons, which corresponds with the average given by American authorities (*Bulletin* 190, *Bureau of Plant Industry U.S. Dept. Agric.*) and is well below the yields of the best lemon plantations.

When one comes to consider profits, it has to be remembered that the cost of handling the lemon crop is much greater than in the case of the lime crop. There are also expenses in connection with irrigation, frost protection, and manuring, and the rental value of good lemon land is higher than that suited to lime cultivation. On the other hand, lime cultivation has heavy shipping freights, though, as a matter of fact, these cannot on the

whole work out much higher than those for lemons and lemon products, considering that Italy sends about half of its crop to the United States.

From the producer's point of view it is clear that the lime can easily compete with the lemon as a source of citric acid. In considering the figures given for lime cultivation, it should be borne in mind that these two are based on conservative estimates and the annual losses are allowed for, which in all probability will be greatly reduced in the near future, as improved methods of preparation are more widely adopted.

Prices are likely to drop immediately in the future. For one thing, the war will interfere with the consumption of fresh lemons, and Sicily will probably make more citrate and oil. Lime cultivators will have to make every effort to improve their yields, which can be done, and to ship concentrated juice, only good quality raw juice, and essential oils. With greater production per acre lime growers can stand a lower market value than the Sicilian growers. Moreover, the West Indies are nearer New York and Canada. Lime cultivation has the advantage over lemon growing in Sicily in this respect also.

Selling Basis of Lime Juice and Oils.—Concentrated lime juice is sold on the basis of its citric acid content. The juice is quoted on the basis of a standard "pipe" of 108 gallons, containing 64 oz. of acid per gallon. A pipe is therefore equivalent to 6,912 oz., or 432 lb., of citric acid.

A West Indian hogshead of concentrated juice (100 oz. per gallon) contains about 52 gallons, and is equivalent to three-fourths of a standard pipe. A pipe contains 432 lb. of citric acid; a West Indian hogshead 325 lb. In commercial analyses the citric acid is mentioned as crystallised acid, containing only half a molecule of water instead of one molecule, as would be done in the case of ordinary analysis.

Gross and Net Values.—Some idea of the net amount realised from the sale of concentrated lime juice can be obtained from the following figures. The expenses are partly fixed and partly based on value.

If the sale price per pipe is £21 the fixed charges

(labour, freight, packing, etc.) amount to about £2 8*s*. 3*d*., and the charges (commission, brokerage, insurance, testing), based on value, come to about £1 0*s*. 6*d*. (=6½ per cent.) on a hogshead (52 gallons). The amount realised for this hogshead gross is £15 16*s*., hence the net value would be £12 7*s*. 3*d*. In the case of essential oils the charges based on value are higher (7½ per cent.).

Net Value per Acre.—Owing to the variation in local conditions, it is not possible to give reliable figures as to the profits made in the case of lemon and lime cultivations, but, based on the values and charges noted above, the net value of lime juice and oil from an acre would be about £35. This does not allow for expenses of production previous to the preparation of the products and their shipment and sale.

According to the French estimate quoted on a previous page, the clear profit in connection with lemon cultivation is about £45 per acre, but apparently this figure does not allow for the cost of marketing. The American authority quoted states that the profit in Italy on 100 lb. of oil and a pipe of citrate of lime is about 60 dollars or £12 10*s*. Satisfactory information on the subject of profits can only be got through access to the accounts of an estate run on commercial lines.

The Marketing of Citrus Products

Methods of Selling in Sicily.—An important feature of the Sicilian industry which distinguishes it from the West Indian is the existence of a Camera Agrumaria or Citrus Chamber, which is a Government Department for regulating market prices. The quotations which are made in London and in other markets by sellers are to a great extent based on the prices quoted by the Italian Citrus Chamber, so that from the West Indian point of view it is an organisation of considerable interest. As a matter of fact, it may be laid down generally that the amount of organisation employed in the disposal of Sicilian citrus products is very great—far greater than in the West Indies, where there exists no central body which can regulate the output in any way. In Sicily, the proprietors generally sell

their crops by contract, before they are gathered, but have to fix a certain latest date for delivery. The sales are effected through intermediate brokers called "country brokers." Occasionally the crop is sold by the thousand at each picking. The buyer usually picks the fruit when it is sold by the season. The grower usually picks it when sold at each picking. Practically none of the fruit is exported by the grower, except occasionally in the case of experienced large producers. As already intimated, the grower usually sells his fruit through a broker to the exporter or the manufacturer of by-products. The broker acts as an agent for both parties in the final settlement of the transaction, often shipping the fruit for the grower, receiving the money, and depositing it or using it in purchases for the grower.

The citrate of lime and concentrated lemon juice are handled exclusively by the Camera Agrumaria, who fix the prices periodically and allot monthly deliveries to the various buyers all over the world through their (the buyers') agents. The lemon oil, however, is extracted by other houses, who each have a distinctive *brand* for their oil, and an agent in the principal markets for the sale of it. It will be seen from this that the Sicilian citrus trade lacks the competition among buyers which is enjoyed by the West Indian trade, and obtained by the methods referred to below.

West Indian Methods.—In the case of the West Indies, each producer, in the ordinary way, ships his own produce; but he may sell the fruit to one of the larger factories. In one instance a Government factory buys fruit or raw juice from the small growers, paying down so much cash and issuing a further amount in the form of a bonus at the end of the year, based upon the actual selling price of the manufactured products. Whatever the local method of disposal, the products are ultimately shipped to merchants at one or other of the principal markets. It should be mentioned here that a system of forward contracts is now being extensively adopted in the West Indies. This should be distinguished from the Sicilian method of crop disposal already described. The West Indian forward

contracts refer to the shipment of juices, citrate of lime, and oils within a definite period at a fixed price. This forward business could be vastly improved, to the mutual advantage of buyer and shipper, if the latter would contract to ship a certain specified quantity each month of the contract period and also to maintain a uniform strength.

Citrus Products on the London Market.—The methods employed in handling West Indian citrus products on the London market are very different from those employed in disposing of the Sicilian products, as will be seen from the following account.

As soon as a West Indian steamer arrives, the total available supplies of concentrated juice and citrate are communicated to the various buyers by the brokers, who invite best offers for the whole or part. The highest bid received by the brokers is then made to the various merchants who are interested, and they decide whether it is to be accepted or not. It is rarely refused, for it is recognised generally amongst the merchants that in this manner the highest price obtainable is secured, as there is always a demand for citric acid materials, and the buyer who needs it most, naturally bids his utmost, knowing that he is in competition.

The raw juice and oils, however, are treated rather differently, for whereas the concentrated juice and citrate are always in demand, and are more or less necessities, the raw juice and oils are comparatively luxuries, and generally in more than sufficient quantities to meet the demand, which is spasmodic. Therefore the sale of these products is a slower business, and requires sometimes a great deal of negotiation.

The samples of the different shipments are exhibited at the broker's sale room, where buyers and sellers are continually being interviewed, and in addition to this the most likely buyers are notified of any fresh arrivals. Samples of these products are also posted to buyers resident in the country or abroad.

The brokers keep themselves advised on all matters likely to affect the prices, and when sales are effected shippers may rest assured that the price arranged has

been fixed after due consideration by the merchants of all the circumstances controlling the market.

It will be noticed here that the system of sales adopted in the case of citrus produce differs from that employed in the case of cocoa or sugar or rubber. In these there is an open sale—an auction; in the case of citrus, the produce is sold by private treaty. It may be questioned whether this system of conducting private sales is in the best interests of the growers. There seems no doubt but that it is quite as satisfactory, for users will often give higher prices privately than they will in public; and, moreover, the broker is better able to find the best buyers, since he is in touch with their individual requirements.

Defects in West Indian Products.—It would seem that the importers of West Indian citrus products have, as regards production, several comments to make that seem quite justified. The quality of the citrate of lime from the West Indies is regarded as highly satisfactory, and there is no need to refer at further length to this product. As regards raw lime juice, it would seem that there is a tendency to ship inferior grades. Heavy arrivals of lower qualities obviously depress the market, whereas the better produce would be likely to maintain high prices. In some shipments the casks are not clean, and very often the percentage of pulp in the juice is undesirably high. It is strongly urged in London that to maintain a steady trade in raw lime juice at remunerative rates, these inferior qualities should not be sent at all.

The shippers would ultimately reap the benefit by the better prices obtained for their smaller output, for there really exists a need for a good Dominica juice of uniform quality. It should be of bright greenish tint, with a small percentage of pulp (floating preferred). It should not be contaminated with iron, and should contain the average percentage of acid. Juice of low test or bad colour is absolutely neglected by buyers while anything else is available, and it does not improve on keeping. Raw juice imported from Jamaica very frequently sells at good prices. This is believed to be the result of not extracting the oil which preserves the juice.

In endeavouring to obtain information concerning the marketing of concentrated juice, the writer was enabled, through the courtesy of Messrs. Ogston & Moore, to compare samples of lemon and lime juice. Generally speaking, it would seem that the Sicilian concentrated juice, such as there is, arrives in a much brighter condition than the West Indian product. Another important point is that Sicilian lemon juice (concentrated) is always of about the same test, whereas the West Indian varies from 50 oz. to 140 oz., making it very difficult for buyers to know what they are getting. It is also worth noting that the calico dyers in Manchester state that West Indian concentrated juice often contains more sediment than is desirable. Because concentrated lemon juice arrives in a more fluid state than lime juice, its employment in the textile trade is facilitated; and, what is equally important to the grower, this condition of the lemon juice makes sampling easier. Messrs. Ogston & Moore state that the variation in the acid content of samples from the same cask of concentrated lime juice is largely due to the viscous nature of the fluid. In connection with sampling and testing there are many difficulties, as is well known to both buyers and growers. It must be borne in mind, however, that the fluctuations work both ways: sometimes an analytical result may favour the grower; at other times the buyer. It is well to mention here that samples of imported citrus products are generally taken at the wharves as soon as the ship is unloaded. In some instances samples go direct, but this is the exception, as the broker is supposed to examine a sample from each shipment and report upon it where necessary. Brokers make themselves familiar with samples in order that they may recommend certain marks for special purposes. The samples are analysed in duplicate, and are kept for future reference.

Citrus Oils.—In concluding this section, a few words may be said concerning the market characters of citrus oils. Citrus oils should be packed only in the best tins, and on no account should distilled oil be mixed with hand-pressed (écuelled). The writer was shown in Mincing

Lane samples of oil which were undoubtedly spoilt in this manner. It should be remembered, in considering Sicilian competition, that the West Indian lime oils are used in the toilet and confectionery trades for different purposes from the lemon oils. Hence whatever the Sicilian production—which cannot increase largely if the fresh fruit trade holds—there will always be a special demand for lime oils from the West Indies, provided that they are of good and uniform quality. In this business, too, the Sicilians have been longer in the field and their lemon oils are prepared with the greatest care, resulting in a uniform article, so that buyers know they can rely upon always getting the same quality. Hand-pressed lime oil, on the other hand, varies tremendously, even from the same estate, and it would be a wise step for a planter to bulk, say, two or three months' product of hand-pressed oil (keeping out any of bad colour) and shipping only two or three times during the season. This would give him a regular quality and his mark would gradually become known on the London market and preference would be given to it by buyers who want an article on which they can rely.

Essential Oils of Oranges

Because of its close relation to lime and lemon cultivation, a few words may not be out of place on the products of the orange crop. These oils, both bitter and sweet, have been produced in large quantities in Italy for many years. Like the oils of lemon and lime, those of the orange are used in perfumery and confectionery. After the Messina earthquake, during which large stocks were destroyed, the buyers in England and elsewhere had to look to other places for their immediate supplies. Some of these were drawn from Jamaica, where orange cultivation is a large but somewhat scattered industry. Hitherto the West Indian product had been too inferior to compete with the Sicilian, but necessity led to the partial substitution of West Indian orange oil for Sicilian. It is worth noting that as the demand sprang up the method of preparing the oils in

Jamaica improved, and it is believed that good prospects lie before West Indian orange oils, provided that only good qualities are shipped. The cost of collection, preparation, and freight appears to be greater in Jamaica than in Sicily, and it would scarcely seem to pay at less than 4*s*. per lb.

Summary of Conclusions

1. The output of lime products in the tropics, although comparatively small, is rapidly increasing. The Sicilian production of lemons is, on the other hand, stationary, but according to the demand of the world's market, this country can increase her output of citrate at the expense of fresh lemons, and vice versa. Lime growers can to a certain extent do the same, but are less able to exert influence in this respect.

2. An examination of figures relating to the composition of the lemon and lime shows that the lime is richer in juice and citric acid than the lemon. But the lemon generally contains more essential oil.

3. As regards cultivation the two crops differ in many respects. Lemon cultivation seems the more expensive owing to the necessity for irrigation, frost protection, and handling, but lemon products can be placed on the European market at less expense than lime products.

4. For purposes of comparison the lemon may be regarded as yielding 634 lb. of citric acid per acre against 914 lb. in the case of limes. The figures for essential oils are 88 lb. and 65 lb. respectively.

5. In view of the probable increase in the Sicilian output of citrate, lime growers might with advantage increase their shipments of concentrated juice of uniform density (about 100 oz. of citric acid per gallon). Only raw lime juice of the best quality should be shipped. Since lime oils are used for different purposes from lemon oils, they cannot be said to come into direct competition unless the qualities of one are so inferior as to permit of the substitution of one by the other. Oils take longer to sell than other citrus products. Lime oils are on the whole more variable than lemon oils.

6. It is not possible on the basis of available information

to compare the profits from lemon and lime cultivation. With good prices it is probable that it is greater in the case of limes.

7. As regards marketing the existence of the Sicilian Camera means lack of that competition amongst buyers which is enjoyed by the lime-growing industry. At the same time the Camera ensures a minimum price for lemon growers.

8. The testing of samples is not as satisfactory as it might be. This is said to be largely the result of variation in the composition of juices in individual shipments.

9. A profitable trade in orange oils might be more generally established in the West Indies.

The writer is indebted to the Director and Staff of the Imperial Institute, where these notes were prepared, for providing facilities and for much valuable assistance in other ways. Acknowledgments are also due to the West India Committee. To Messrs. Lewis & Peat, 6, Mincing Lane, E.C., the writer is indebted for most of the observations on the marketing of citrus products. Thanks are due to Messrs. Ogston & Moore, Analytical Chemists, for their views connected with the same subject.

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GENERAL ARTICLES

THE POSSIBILITIES OF SERICICULTURE IN BRITISH COLONIES AND DEPENDENCIES; WITH SPECIAL REFERENCE TO THE REARING OF WILD AND SEMI-WILD SILKWORMS

The greater part of the world's commercial supply of silk is obtained from the cocoons of the common mulberry silkworm (*Bombyx mori*), the rearing of which is an industry that has now attained a high degree of complexity. The larvæ of several other moths, occurring wild or semi-wild in various countries, also yield silky fibres; these products, although not having quite the brilliancy and attractiveness of mulberry silk, are nevertheless made into yarn and cloth possessing very desirable qualities, such as strength and durability, and commanding a ready sale. The provision of scientific aid for these industries is well worth the attention of Indian and Colonial Governments. Information about the more important of these insects, their rearing and their products, is given in the following pages, preceded by a brief survey of the possibilities which they offer for exploitation in British Colonies and Dependencies.

The most important wild silkworms in Africa belong to the genus *Anaphe*. In all the species a number of the larvæ co-operate to spin a large case or "nest" some inches in length, in which they collect and spin their own cocoons. This Anaphe silk has attracted a good deal of attention in recent years, and yarn and cloth have been spun and woven from it. The masses are collected and brought in for sale by the natives in various parts of Africa. The life cycle of the insect unfortunately approaches, and sometimes exceeds, a year in length; consequently, in the opinion of Prof. Maxwell Lefroy, it would not repay the trouble necessary to try to domesticate it (in the sense of rearing it indoors), even if it were possible to do so, especially as the silk does not approach mulberry silk in value. The natives, however, should be encouraged to collect and sell what they find on the trees, and they might be induced to concentrate the broods of worms on trees near their homes just as the Sonthals do with the Tussar silkworms in India. The feasibility of the latter method has been tested by experiments made by the Government Entomologist in Uganda (see p. 109).

Of the Asiatic insects, the eri silkworm (*Attacus ricini*) promises to be well worth trying in Colonies where the climate is suitable, namely, those with a temperature range of 60° to 90° F. without great dryness of the air, provided that labour is not too scarce or dear. Women and children, however, could take part in tending the worms. The food of this insect, the castor-oil plant, grows like a weed in the West Indies, Ceylon, and other tropical countries, and is very easy to cultivate. The worm is quite domesticated, since, like the mulberry worm, it will feed on leaves brought into the house, and will go through all its stages indoors; thus it is completely under control, and can be protected from its enemies. It can also stand higher temperatures than the mulberry worm, but is not so easy to rear; nevertheless, its exploitation is simpler, for the silk is not reeled but spun, the chrysalis does not have to be killed, and the cocoons, after the moths have emerged, only require to be turned inside out and cleaned, and can then be packed closely in bales for export. Mul-

berry cocoons must have the chrysalides killed, and then must either be reeled locally, an operation which requires skill, or else must be loosely packed for export, thus increasing the freight. Experiments have been carried out on the rearing of the eri silkworm by several Agricultural Departments in India, and trials on an industrial scale have been made at the various silk farms conducted by the Salvation Army in India and Ceylon, with satisfactory results. The worm has also been tried in the Philippines with favourable results.

The whole industry was very carefully investigated for several years by Prof. Maxwell Lefroy at the Agricultural Research Institute at Pusa in India. Using his results as a basis, experiments in the rearing of this insect should be instituted in the Coloniès, in order to ascertain whether any local variations in procedure are necessary, and in the event of the trials proving satisfactory efforts should be made to introduce the industry to the natives as a means of increasing their earnings. In doing this care should be taken to provide the natives with facilities for marketing their produce.

As regards the prospects of profit from the eri industry, Prof. Maxwell Lefroy found that it cost 40 rupees (53*s.* 4*d.*) to produce a maund (82 lb.) of the cocoons, out of which 25 rupees (33*s.* 4*d.*) was spent in labour, a man being employed as a rearer at 9*s.* to 10*s.* a month. As a family industry, with the aid of women and children, the cost would be less than using hired male labour. The price of cocoons was about 75 rupees (£5) for 82 lb. The demand for eri cocoons is fluctuating, largely because the supply is uncertain; the silk is spun into thread by Yorkshire and Continental mills.

There are two other silk-producing insects in India, namely tussar (*Antheraea paphia*) and muga (*A. assama*), but the worms of these will not feed on leaves brought indoors, and must be allowed to live on trees in the open; consequently a constant watch has to be kept to drive off birds and other enemies that prey upon them. The first is reared by the Sonthals, who have engaged in the industry for ages, and the second by the Assamese. The

tussar insect has to be hatched on the tree, and must be allowed to feed and to spin on the tree; the laying of the eggs is the only stage that can be done in the house. The muga insect is a little more domesticated, since it spins indoors, the moth emerges indoors, and the eggs hatch indoors, after which the young worms are transferred to the trees to feed. The rearing of neither of these insects seems to offer much hope of extension, except perhaps in India and Ceylon.

It thus appears that the two forms of sericiculture which merit trial in new regions are the rearing of the mulberry worm and of the eri worm. The mulberry worm produces the more valuable product, but the reeling of the silk is a matter requiring great skill, whilst it is a much simpler matter to produce and pack the eri product for export if it cannot be spun and woven locally; it seems desirable, therefore, that trials of both should be made in those parts of the British Empire in which the establishment of a silk industry appears to be feasible.

Eri Silk

Eri silk is the product of the caterpillar of *Attacus ricini*; this worm feeds on the leaves of the castor-oil plant, *Ricinus communis*, and is reared in Assam. As already mentioned, the worms, like the mulberry silkworm and unlike those that produce tussar and muga silks, can be fed indoors, but the cocoons, unlike those of the other three insects, cannot be reeled and must be spun, as the thread is not continuous. The chrysalides in the cocoons are usually killed, but this is not necessary, and it is better to let the moths emerge. The cocoon is composed of a cradle, of three to seven detachable layers, and an inner portion, where the thread gets weaker and is much covered and cemented with gum, forming a shiny, smooth layer. One end is hard and even, and the other loose and blocked with loops of silk, so that nothing can get in, but the moth, when it emerges from the chrysalis, can push its way out.

Eri silk has the advantage of taking dyes well; it

can be spun just like cotton, is readily woven, and yields a cloth far surpassing cotton in durability.

Food.—The castor-oil plant, *Ricinus communis* (*eri* in Assamese), on the leaves of which the worm feeds, is a native of India, but is now widely distributed over the warmer regions of the globe, and throughout the Mediterranean region, including Spain, Crete, and Sicily. The worm is also said to eat the leaves of *Heteropanax fragrans*, *Jatropha Curcas*, *Zizyphus Jujuba*, *Gmelina arborea*, *Carica papaya*, *Plumeria alba*, and *Manihot* spp.

Rearing.—As many as eight broods can be obtained in the year, but in Assam only five or six are actually reared, mostly in the cooler months. The care of the worms is generally undertaken by the women of the family. The following is an account of the native practice given in *Indian Museum Notes* (1890, **1**, 164): The cocoons reserved to yield eggs are placed in a round basket of woven bamboo with a narrow mouth, which is hung up in the house out of the way of rats and insects. After a time, lengthened by low temperature, the moths emerge, and are allowed to move about in the basket for twenty-four hours. The females are tied to pieces of reed or straws by a thread passing round the joints of the wings on one side of the body, leaving the other two free, about ten moths being tied to a piece of reed two feet long. The males are allowed to fly about and fertilise the females; any unfertilised females are placed outside the house in the evening and attract stray males. The eggs are picked off the straws, and wrapped in a piece of cloth which is hung up in the house. In May, with an average temperature of 83° F., the eggs hatch in a week or less, but in winter hatching takes about fifteen days. Tender leaves of the castor-oil plant, previously crushed with the fingers to render them softer, are given to the young worms, which later are transferred to a bamboo tray suspended in a place of safety. As they grow bigger, older leaves are given to them. When first hatched, they are about ¼ in. long, and when full-grown about 3½ in.

After the last moult the worms are transferred from the tray to forked twigs of the castor-oil plant with the

leaves on, suspended across a piece of reed. As the worms mature they stop feeding and crawl to the top of the fork; they are then placed to spin in a bundle of dried plantain leaves, or of branches of trees with withered leaves attached, which is suspended from the roof. The cocoons are about $1\frac{1}{5}$ in. long and $\frac{3}{4}$ in. in diameter, and either white or of a brick-red colour. The chrysalides are killed by exposing the cocoons to the sun for one or two days, or by heating them in bamboo trays over a fire. The cocoons are softened by boiling them in an alkaline solution of plant ashes; they are then opened to remove the chrysalides, and the silk is washed and dried in the sun ready for spinning. It is spun by hand into a more or less uneven thread, which is woven in Assam into a coarse but soft and durable cloth.

With a view to spreading the industry in India if it should prove to be a profitable undertaking, it has been carefully studied at Pusa, where trials of rearing the worms have been made. The following recommendations are taken from *Memoirs of the Department of Agriculture of India, Entomological Series* (1912, **4**, 1), by Lefroy and Ghosh.

The eggs should be put in a tray or other vessel into which the air can enter. In very dry, hot weather the tray should be covered with a damp cloth, such as a wet gunny. In very cold weather, it should be covered with a damp cloth and put in the sun, taking care that the cloth does not get dry; at night no covering is needed. When the eggs turn grey they are going to hatch, and should be spread out evenly and covered with the smallest castor leaves. The worms crawl on to these, which can then be transferred to the feeding trays; here they should be given small castor leaves twice a day. The young worms require great care, and must not be mixed with older ones. All that hatch on the same day should be kept together, except that larger worms should not be kept with those whose growth is less rapid. The leaves should be torn into two or three pieces; they should not be chopped up, as then they lose their moisture too quickly. In dry weather, as the leaf dries, the worms should be given fresh leaves three or four times a day; the trays may be covered with wet

cloth to retard the drying of the leaves. In very cold weather the tray of young worms covered with a wet cloth should be kept in the sun. The worms should be handled as little as possible, and then very gently. Each day the worms, as soon as they have crawled on to the fresh supply of leaves, should be transferred to a fresh tray and the old tray should be cleaned.

After a few days the worms stop feeding and look sick; this is a sign that they are going to moult, and must be left alone; when the moult is over they become restless and want feeding again. Some die at this moult. If the season is favourable and the leaves do not get dry the feeding must be continued as before, using larger leaves and an additional feed at night-fall. In a few days they will have their second moult. After their third moult they should be fed three times every day and once at night. In hot weather, if the leaves get dry or if the worms are restless, they should be fed oftener. After the fourth moult, which is the last, they want feeding four times during the day and once or twice at night. Restlessness is a sign that more food is wanted. The worms should never be fed when moulting, and they should not be overcrowded. The leaves should be neither wet nor dusty, and the leaf-stalks should be removed.

When the worms are full-grown, and cease feeding and move about, it is a sign that they want to spin. They do this between 9 and 12 o'clock in the morning. If a worm is held near the ear and the fingers are passed along the fleshy spines, a hollow sound will be heard from a worm ready to spin and a dull sound from others.

When getting ready to spin the worms deposit much excrement and crawl to the edge of the tray; they should then be collected from the edge and placed in the spinning baskets. These must be ventilated; loosely woven fruit baskets are suitable. A layer of crumpled paper, or chips of dry straw, or dry leaves, should be put on the bottom; the worms are put on this, and then other layers of material and worms until the basket is full. The lid is then put on, taking care that there is no empty space beneath it. The lid is next weighted down or the basket is turned upside

down. About 500 worms can be put in a basket $1\frac{1}{2}$ ft. in diameter and $1\frac{1}{4}$ to $1\frac{1}{2}$ ft. in depth; they should not be overcrowded. After five days in hot weather or eight days in cold, the cocoons should be picked out and spread evenly on trays. Some cocoons are white, others reddish-brown; the latter are not so desirable, and can be eliminated in the course of three or four generations by selecting only white cocoons for obtaining eggs for hatching. After the cocoons have been spread out for ten days in summer, or up to forty days or more in winter, the moths emerge. They should be left alone for some hours and then placed inside an empty basket on the sides, placing a large-bodied moth (female) and a small-bodied moth (male) side by side. The basket is then covered. The next day the moths that have not coupled are removed, and the coupling pairs are left in the basket for another day. Then the females are removed, separating them from the males if they are still coupling. The males are to be thrown away and the females put in a separate basket to lay eggs. The best eggs are laid the first night, about 80 per female; these are to be scraped off with a blunt knife or stick and kept for hatching; those laid the second and third nights may be used if there is a deficiency of eggs, but otherwise they should be rejected. The moth lays about 200 eggs and requires no food. From 100 eggs, 90 moths may be obtained, of which perhaps 40 will lay eggs, thus yielding about 8,000 eggs. Care should be taken not to hatch out more worms than can be fed.

Preparing the Cocoons for Spinning.—When the moths have all emerged, the cocoons should be picked over to remove straw, etc. They are then soaked in water for eighteen hours, and afterwards washed well to remove all dirt, squeezing them with the hands. They are next tied up in a cloth and dropped into a boiling solution of washing soda, in which they are kept submerged by a brick or other weight, and boiled for three-quarters of an hour. One pound of cocoons requires about $2\frac{1}{2}$ gallons of water in which 4 oz. of washing soda have been dissolved. The bundle is removed, and without being untied is washed until the water runs away clean from the cocoons, and it is

then squeezed. The cocoons can be spun wet if the spindle or the continuous spinning machine is used, but must be dried thoroughly if the country spinning wheel is employed. Dry cocoons can be spun and carded like wool. One pound of cocoons gives 10 to 12 oz. of thread. Good cocoons weigh 1,250 to the lb. after the moth has emerged, small ones 1,750 to 2,000 to the lb.; 75 lb. of leaf feeds sufficient worms to yield 1 lb. of cocoons.

When the moth emerges from the cocoon it leaves behind both the old caterpillar skin and the chrysalis case, and sometimes excrement too. It is plain that it would be a great advantage if these were removed before spinning, and an appliance, known as Coryton's machine, has been devised which effects this by turning the cocoons inside out; it is made in two forms, a simple one to be worked by hand, and a more complex one to be worked either by hand or power.

Climate.—Besides the question of a good supply of castor leaves, the climate is a most important factor in the success or failure of the industry. At Pusa, trouble was caused both by the low temperature, which may fall as low as 40° F. in December, and also by the dry, hot west winds. The conclusions arrived at were that if worms are coming on to spin at times when the temperature falls below 50° F., it is probable that many of them will die; on the other hand, temperatures above 105° F. are also injurious, but more to the quality than to the output of cocoons. The best conditions seem to lie between 60° F. and 90° F.; possible conditions between 50° F. and 100° F.; and difficult conditions, necessitating great care, when the temperature goes for any long period over 100° F. or under 50° F. The most critical stages are when the worms are spinning and the moths emerging. At other stages cold is not serious; with a minimum temperature somewhat below 50° F. the chrysalides remain healthy in the cocoons, eggs remain healthy, and do not hatch, and young worms remain healthy, feeding little; but if cold supervenes while the worms are spinning, or the moths coupling or egg-laying, the temperature must be kept up to 70° F. at least, and if possible up to 75° F. for three days.

Diseases and Enemies—The eri worm suffers from diseases, which are the same or similar to those of the mulberry worm. Pébrine has been found to occur, but has not become of any importance, and does not yet necessitate the microscopic examination of the moths. A disease similar to muscadine occurred in one brood, but did not spread; disinfection of all trays and baskets is important in such a case. A disease similar to flacherie has also occurred; bad feeding, bringing the leaves long distances, bad management, want of cleanliness in the trays, and bad climatic conditions are likely causes of this.

A parasitic fly of the family Tachinidæ lays its eggs in the worm, and its larvæ feed inside the latter and destroy it or the chrysalis. Great care should be taken not to introduce this pest into new localities. In these, the industry should always be started from healthy eggs, as they cannot carry the parasite. Cocoons should never be employed for the purpose, as they may contain the enemy, especially those from Assam.

Rats are serious enemies in all stages, especially of the chrysalides in the cocoons. They can be combated by the use of traps and poison, and by keeping the cocoons in closed baskets suspended by string. Ants attack the young worms, and may be kept off by smearing the legs of the stands supporting the trays with tar or crude oil emulsion. Bats also attack the cocoons.

Conditions for Success.—A suitable climate and an adequate supply of castor-oil leaf are the first considerations. The leaf is probably unsuitable if on the one hand it is very old or if, on the other hand, it has grown quickly after pruning in warm, moist weather; in this case its unsuitability is perhaps due to its high moisture content. The aim should be to pluck all full-grown leaf before it gets old, but not to be obliged to strip all the leaf at any one time, and to arrange the number of worms so as to use this leaf. For one acre of castor-oil plant six regular broods of 30,000 worms are better than irregular broods with one large brood. By growing perennial castor-oil plant, one crop can be arranged to overlap another, and so meet the requirements of regular, even broods. These

matters, however, must be arranged to suit the local conditions. Another matter to be seen to is the facilities for the disposal of the cocoons, or yarn, or cloth.

The question of the profit to be made when the industry is carried on on a fairly considerable scale with hired labour has already been dealt with (p. 89). The opinion is held that rearing in small lots by cultivators is the best plan, and that a return of 1 rupee per seer (1*s.* 4*d.* per 2 lb.) should induce them to undertake it. It is also considered desirable to have the silk spun into yarn by women locally, and then to have the yarn woven into cloth by weavers, provided that they can turn out a good and marketable quality of cloth, for which there is a demand in certain parts of India. Mill-spun eri, too, might meet with an immense demand in India and in Europe.

Tussar Silk

Tussar (or tasar) silk is the product of the caterpillar of *Antheraea paphia*, which occurs wild in many parts of India in jungle land up to an elevation of 4,000–5,000 ft., where the cocoons are collected by men and women in the course of other employment. Some cocoons are also produced as a special industry carried on by certain natives on the Central Indian plateau. Although the worms cannot be profitably reared in sheds or houses, they can be propagated on trees devoted to the purpose, where they can be supervised and protected to some extent from their enemies. The worm spins a cocoon which is attached to the food plant by a strong silken stem, and which contains a large amount of course, strong, buff-coloured silk. The thread is continuous, so that the silk can be reeled like that of the mulberry silkworm, provided the chrysalis is killed before the moth emerges, as the latter in escaping from the cocoon excretes a liquid which softens the walls of the cocoon and spoils it for reeling.

Feeding.—The worm feeds on the leaves of many kinds of trees, and, as a rule, it will eat the leaves of any tree on which it is put at first; after having fed, however, on the leaves of one kind of tree for a number of days, it will not, as a rule, eat the leaves of another. The asan

(*Terminalia tomentosa*) is the most suitable, as it can withstand a great deal of lopping, and to transfer worms from one tree to another it is necessary to cut off the branches on which they are situated. This and the sál (*Shorea robusta*) are the trees on which the worm is usually reared.

The habitat of the tussar silkworm is high up in the trees of the open forest, and it will not eat the leaves of low-growing bushes or those of branches brought indoors, though some success can be obtained by hanging branches high up in a verandah, sprinkling them occasionally with water from the rose of a watering-can to imitate rain, and daily putting fresh branches in contact with the old. It will not eat strong-smelling or bitter leaves, or those repulsive to the touch.

Rearing.—The Sonthals of Bengal have reared the tussar cocoons for ages, and have brought the system to a high degree of perfection. The first step is to search for seed cocoons; to do this the Sonthals examine the ground in the jungles closely for the droppings of the worms, as it is hopeless to try to see the worms on the branches. If the droppings are small they are neglected, as the worm has not reached maturity, but if sufficiently large, the men climb the tree and obtain either the cocoon or the worm just ready to spin; large cocoons are preferred, as these are more likely to produce female moths. Either wild cocoons thus collected or cocoons obtained in the course of the regular industry are used to supply a crop of the worms.

The cocoons are not kept in the house, but are hung in clusters on the top of a pole in the open yard. This pole has a straw thatching at the top to protect the cocoons from sun and rain. When one or two moths are seen to have come out, the pole is taken down and the cocoons are strung on the bamboo parts of a number of bows; these are suspended by ropes from trees so that they can be raised or lowered at will. The moths begin to emerge at nine or ten in the evening; the males fly away, but the females, which usually come out first and are larger than the males, remain quietly on the bows. From midnight

till the early morning males, which as a rule are strangers and not those that flew away on emerging, are attracted to the bows. In the morning the bows with the moths on them are brought indoors, and in the afternoon the females are put in closed vessels made with large leaves fastened together with hard leaf stalks. As a rule two female moths are put into each vessel, the mouth of which is then pinned up with leaf stalks, so that the vessel remains distended. The moths make attempts at flight, and at each attempt lay a few eggs. In the natural state, the moths fly from one tree to another and lay eggs, a few on each tree. The vessels containing moths emerging on different dates are kept separate. The egg-laying is nearly finished in the night following the enclosure of the moths. After five days the vessels are opened, the moths are thrown away, and the eggs are carefully picked or scraped out and gently rubbed between the palms of the hands and the dust and down on them are blown away. The eggs are then put into little cups made of leaves, and these are pinned by means of leaf stalks on to the leaves of growing trees, two or more other growing leaves being pinned down so as to form a cover and prevent rain-water entering the cup or a high wind upsetting the eggs. Ants are kept off by a circle of the oil of the bholá (*Semecarpus Anacardium*) round the trunk of the tree. The worms hatch out on the eighth day. The trees are now watched all day to drive away the enemies of the worm, such as ants, wasps, birds, bats, and jackals. The watchers are armed with bows and bird-lime, and employ their time in weaving nets or spinning thread. Small trees are the most convenient, as then the branches can be easily lopped off and transferred to other trees when the leaves are eaten. Pollarded trees are employed for the purpose.

Broods.—The time spent in the chrysalis state is very variable, ranging from less than a fortnight to six or seven months. From light-coloured cocoons with long stems the moths emerge soon after spinning, but from large and dark-coloured cocoons with short stems they take six or seven months to emerge. Owing to this the seasons of the broods are not very definite, and large

and small worms can be seen at all seasons, but roughly there are three broods in the year.

From the cocoons set apart for propagation in October a few moths emerge from time to time in November, December, and January, but the majority emerge in February. The eggs from these hatch after eight days; the worms feed for two months and then spin cocoons in April. When first hatched the worms are about ¼ in. in length; when full-grown they sometimes reach 7 in. Since the hardy, dark, short-stemmed cocoons mature very irregularly, those with long stems and of small size are selected from this brood to yield eggs, as the moths from them come out at the same time. Unfortunately, they contain the feeblest insects, and to this may be due the fact that after a few generations the cultivated insects are attacked by disease, and a supply of wild cocoons must be obtained. This second crop of moths emerges towards the end of May, the eggs hatch after eight days, the worms feed for a month and a half and spin in the middle of July. The rapidly developing cocoons are again selected for propagation so that the moths may emerge together; this occurs about the first week in August, and the worms from them, after feeding for two months, spin about the middle of October.

The Sonthals take three, four, or five broods in succession of these feeble insects and then resort to hardy wild cocoons for further broods. As the males that mate come from the jungle and are subject to no selection, it seems that there is here an opening for improvement, and that by careful selection of both sexes used for breeding, production of cocoons maturing at definite times might be obtained, and also control of the quality of the silk. In cold hill countries moths emerge only once in the year, whilst in Lower Bengal rearing goes on all the year round, but in larger quantity at the three recognised periods, the rainy season being the principal one.

Diseases.—If the leaves of the trees are too succulent, or if the heat is too intense when the worms are in their last stage, they are liable to die off in great numbers

from grasserie; this happens chiefly to the second and third broods of the year and is probably due to breeding from weak insects. Rain every now and then has a beneficial effect, and its absence or excess are both injurious; when the worms are feeding upon the trees in the open, heavy rain is almost of daily occurrence. Many die from parasitic attacks of Ichneumonidæ and Tachinidæ. *Masicera grandis* is a very destructive parasite.

Reeling.—Tussar silk is more difficult to reel from the cocoons than mulberry silk, and the cocoons must be boiled in an alkaline liquid preparatory to this operation. The natives add the ashes of plantain leaves to water and boil the cocoons in this for two or three hours, and then leave them to ferment for some hours before winding. In some factories in Bengal, the cocoons with their stems cut off are tied up loosely in a cloth; this is weighted down with stones and boiled for half an hour in a solution containing three parts of potassium carbonate dissolved in eighty parts of water, oil and sugar being sometimes added. The cocoons are afterwards boiled for a few minutes in water containing a little glycerine. The silk is then reeled in the same way as mulberry silk. The glycerine keeps the cocoons moist whilst reeling, and it is not then necessary to keep them in basins of water during this operation. Another method is to prepare a fine powder or paste from the chrysalides of tussar or mulberry insects; about one part by weight of this is mixed with two parts by weight of dry cocoons and the mixture is tied up in a cloth, weighted, and immersed in water, which is then boiled for an hour. The mixture is next left to ferment for twelve hours, after which reeling begins, the cocoons being allowed to rotate in basins of hot water just as when mulberry cocoons are reeled.

The reeled silk obtained by any of the above processes must next be immersed in a warm acid solution, then washed in a bath of boiling soap or washing soda solution, and finally rinsed in boiling water, wrung, dried, and baled for export. The object of the acid bath is to neutralise the lime and alkali, which would lessen the brilliancy and elasticity of the fibre; it can be prepared

from tamarinds, using one part by weight of tamarinds in water to every four parts by weight of tussar thread. The tamarinds are washed and mixed with water and the liquid is strained through a cloth. The treatment with soap or washing soda can be omitted, but the final rinsing with boiling water must be done.

One man can reel about 260 tussar cocoons in a day, obtaining eighteen to twenty tolas (about half a pound) of silk.

It is stated that one difficulty in reeling tussar silk is to make the separate strands cohere in the reeled thread; in the case of mulberry silk the cement is only softened in the reeling basin, and hardens again, gluing the strands together.

Muga Silk

Muga silk is the product of the caterpillar of *Antheraea assama*, which is reared in Assam. This insect is allied to the tussar, but is somewhat more domesticated, as it both hatches and spins indoors, though it feeds in the open. The cocoon has no stem, and the silk is more glossy than Bengal tussar. Like the tussar cocoon, the silk can be reeled, and the chrysalides are killed either by exposure to the sun or over a fire.

This insect seems preferable to the tussar in several respects; the time spent in the cocoon is shorter, the caterpillar is more manageable, and the cloth woven from its silk is more brilliant.

Feeding.—The worm is chiefly reared on the sum tree (*Machilus odoratissima*) and on the sualu tree (*Litsea polyantha*), the silk produced from the former being considered to be more delicate than that from the latter. The worm will also feed on other trees; in its maturer stages, if the supply of its staple food runs short, it will eat the leaves of the dighlate tree (*Tetranthera glauca*), the patichanda tree (*Cinnamomum obtusifolium*), and the bamroti tree (*Symplocos grandiflora*). By feeding it on the mezankuri tree (*Litsea citrata*) the character of the silk is changed, becoming fine and almost pure white and much more highly valued, but this is only the case when the tree is young and shrub-like; in the second year of its growth

the silk produced is coarser, and in the third year the silk is scarcely distinguishable from common muga. Similarly when the worm is fed on the champa tree (*Michelia* sp.) the silk is whiter and of better quality than the common muga.

Rearing.—There are about five broods in the year, but few localities rear all five, some localities rearing at one period of the year and other localities at another. The cocoons intended to yield eggs are placed on trays of woven bamboo and are hung up in the house. After about a fortnight in the chrysalis state in the warm months, and after three weeks or a little longer in the cold season, the room then being warmed by a fire, the moths emerge. The female moths, which have longer bodies than the males, are tied by a thread passing round the thorax behind the wings to pieces of straw, which are hooked on to a line stretched across the room, or else several moths are fastened to bundles of straw 18 in. long and 1 in. in diameter. The males are left free, and fertilise the females, though some fly away in the open air; if there is a deficiency of males, the females are placed outside in the evening, when the males will come to them. Each female produces about 250 eggs in three days; the moth lives for a day or two more, but eggs laid after the first three days are rejected as being likely to produce feeble worms. The straws with the eggs on them are placed in a basket covered with a piece of cloth. These eggs are kept in a room warmed by a fire in winter, or they may be set in a place warmed by the sun, but not in the direct rays, as this would destroy them. They should be kept in the dark as much as possible. After from seven to ten days, according to the time of the year, they hatch. In the summer months the eggs can be placed on the trees at once, but so as to be protected from sun, rain, and dew. When hatched the worm is about ¼ in. long, and when full grown it is about 5 in. long and nearly as thick as a forefinger. To set them feeding a triangular tray containing the young worms is pushed by means of a long bamboo among the branches of the food tree, and is hooked on to these. If the leaves of a tree on which they are feeding become exhausted the worms descend the tree

until they reach a coil of straw rope or a band of plantain leaves placed there for the purpose; from this they are removed and placed on another tree. They may be either placed on the trunk to crawl up or be pushed up in a tray as before. Young trees are considered best to begin with. Old trees are avoided as they harbour ants, and the moss on their branches impedes the movements of the worms; trees of three to twelve years are considered the best. The worms feed from about eight till near noon, and then descend the trunk to bask in the sun; they feed again from three till sunset, and at night they shelter themselves under the leaves.

They require careful protection from their numerous enemies, which are crows, kites, owls, and other birds, bats, wasps, ants, and ichneumon flies. Ants are combated with fire and hot water, and by fastening bits of fish to the tree trunks to attract them and prevent them ascending the trees. The watching is very troublesome, and is usually done by children and old people. Continued heavy rain is apt to wash the worms off the trees, but during passing showers they take shelter under the leaves. Hail storms are much dreaded, as they kill numbers of the worms and the survivors are so weakened that they die before maturity or spin imperfect cocoons which yield weak moths.

The caterpillar stage lasts from twenty-six days in summer to forty days in winter, and has four moultings. When mature the worm descends the tree to the edge of the plantain leaf band, and remains motionless, with the fore part of its body raised and thrown slightly back; a peculiar sound, too, can be noticed if the body is lightly tapped. Such worms are removed at nightfall and carried to the house, where they are placed on a bundle of branches with dry leaves attached, in which they spin. The complete cycle of the insect lasts about fifty-four days in the warm months and eighty-one days in the cold season.

Diseases.—The worms are liable to an epizootic disease known as "the swelling," which occasionally destroys the insects on acres of sum forests, and even if some survive

their silk-producing power is impaired. They also often die off in large numbers without any swelling or external symptom, merely ceasing to feed; in this case, too, the yield of silk from the survivors is poor.

Apart from these causes, it is said that some worms can be distinguished as destined to die before maturity; others spin cocoons yielding a deficient quantity of silk.

Reeling.—The cocoon is about 1¾ in. long by 1 in. in diameter, and of a golden-yellow colour, but there are usually a number of dark cocoons in every brood. With the living chrysalis inside, the cocoon weighs about 66 grains, with the dead and dried chrysalis 27½ grains, and the empty cocoon from which the moth has emerged only 6 grains. The cocoons intended for reeling are exposed to the sun or are held over a fire to kill the chrysalis, and before reeling are boiled in an alkaline solution to soften them. The outer layer or floss is pulled off and the cocoon is reeled from a vessel of warm or cold water, from seven to twenty filaments being united in one thread, and the whole cocoon, except the innermost layer next the chrysalis, is unwound. The cold-weather brood gives the least silk and is usually reserved for breeding, only the inferior cocoons being reeled. One thousand cocoons of the winter brood yield about ¼ lb. of thread, and of the spring and autumn broods up to ½ lb. It is probable that the killed cocoons could be kept for two years or even longer before reeling, though they are usually reeled within a year. The floss, as well as the silk immediately round the chrysalis that is not reeled, and the cocoons from which the moths have emerged, are utilised by spinning instead of reeling.

The cloth woven from muga yarn is yellowish, and resembles tussar cloth in consistency, but, as previously mentioned, it is much more brilliant; it stands washing much better than other silks, keeping its gloss and colour.

African Wild Silk

There are various insects in tropical Africa which produce silk. The most important of these appear to be the different species of *Anaphe* belonging to the family

Eupterotidæ, which have been observed in many parts of East, West, and South Africa.

These silkworms are gregarious; at a certain point in their development they assemble in groups and co-operate in weaving a silken nest or colony within which each worm spins its own cocoon. These nests or aggregations of cocoons vary considerably in size and also in form. Some contain several hundred cocoons, whilst others contain only ten or even fewer. With several species, such as *A. infracta* and *A. venata*, the nests are hollow and more or less spherical in form, whilst with other species, such as *A. Moloneyi*, the colony takes the form of a flat mass. In the former case, the envelope of the nest usually consists of three layers of silk. The outer layer is somewhat closely spun, and more or less papery in texture; beneath this is a more loosely spun portion which presents the appearance of a number of superposed sheets of silk; the innermost layer is hard and parchment-like. In the second case, the flattened mass consists of closely-packed cocoons, and is covered on each side with a papery layer of closely interlaced silk. The individual cocoons in the nests are composed of fine silk, but their value is diminished by the presence of much dirt and foreign matter. The cocoons in the interior of the nest are of a paler colour than the exterior, probably on account of the obscuring of the light.

The occurrence of the wild silkworms in Nigeria and the Gold Coast, and their utilisation by the natives, were studied by Mr. G. C. Dudgeon during his tours in West Africa as Inspector of Agriculture during the years 1906–1910, and specimens of the silk were furnished to the Imperial Institute.

In the Southern Provinces, Nigeria, the silk is known as "sanyan," and is employed by the natives for making the so-called sanyan cloths. For this purpose, the whole cocoon mass is boiled with water and wood-ashes, and is subsequently washed with water, and spun on small hand spinning-wheels by the women. The yarn thus obtained is woven in the native looms in admixture with cotton in order to produce cloths with a brown and white pattern.

In the Ibadan district the cocoon masses are furnished by *Anaphe infracta* and *A. venata*, whilst in Agege they are yielded by *A. Moloneyi* and probably other species. In the Ibadan and Oshogbo markets the whole nests are sometimes offered for sale, but sometimes only the enveloping layers are marketed, the pupæ being previously removed and eaten as a delicacy. There is probably a good demand for sanyan throughout the Yoruba country. A white form of the silk, known as "Cambari" sanyan, appears on the Oshogbo and Ibadan markets. This is said to be produced by collecting the larvæ and enclosing them in calabashes, where they spin white silk instead of brown. It has been found by experiments at the Imperial Institute that when worms of a species normally yielding brown silk were confined in a dark box, they produced a white silk, thus proving that the production of the white silk is due to the absence of light. In the Yoruba country the principal food-plants of *Anaphe infracta* are *Albizzia fastigiata* and a species of *Sterculia*, whilst *A. Moloneyi* in the Agege district feeds chiefly on *Cordia Milleni.*

Nests of *Anaphe venata* are very commonly met with in Northern Ashanti on a great variety of plants. These worms do not usually congregate in such large numbers as those of *A. infracta* and *A. Moloneyi*, and the nests usually do not contain more than about twenty cocoons.

In the Northern Provinces, Nigeria, there are four kinds of silk recognised. In the case of the most valuable kind, which is known as "tsamian tsamia," the silkworms are said to congregate in hollows and crevices of the trunks of *Tamarindus indicus* (the "tsamia" tree), on the leaves of which they feed. This worm is probably a species of Anaphe, but has not yet been definitely identified. The silk realises a high price and is utilised for making the embroidery for Hausa gowns. A second kind, "tsamian doka," consists of the flattened masses of cocoons characteristic of *A. Moloneyi*; this worm feeds on *Macrolobium* sp. The two other kinds of silks are of inferior quality.

Several species of the Anaphe silkworm occur in Uganda, of which the principal is *A. infracta*. A thorough investigation of this silk has been carried out at the

Imperial Institute, with the results stated below. In 1909 a specimen silkworm was received from Uganda and was identified at the Natural History Museum as an abnormal type of *A. ambrizia*. Other kinds which have been observed are *Hypsoides milleti* and *Mimopacha gerstaeckeri*, but neither of these is abundant. The Anaphe worm feeds on the leaves of *Bridelia micrantha*, *Cynometra Alexandri*, and *Triumfetta macrophylla*.

Anaphe silk contains a considerable quantity of "gum" which is more resistant to the action of the usual degumming agents than that of mulberry silk or tussar silk. In a series of experiments at the Imperial Institute the best results were obtained by boiling the silk, first in a 3 per cent. solution of washing soda, and afterwards, without intermediate washing, in a solution of soap of the same strength. The amount of clean, degummed silk obtained at the Imperial Institute from a sample of nests from Uganda was as follows: 100 lb. of the crude nests, on being freed from chrysalides, twigs, and other extraneous matter, yielded 41 lb. of the silk envelopes, which contained about 18 per cent. of gum; 100 lb. of the nests therefore furnished about 33·5 lb. of clean, degummed silk. The degumming process should not be attempted in the country of origin, as the silk is liable to be injured unless the process is carried out with great care, and for this reason European spinners prefer to treat the silk by their own methods.

The African wild silk cannot be reeled, as is done in the case of mulberry silk, and it is therefore carded and spun as "waste" silk. The product has been found suitable for the manufacture of velvet, plush, sewing silks, and other materials. Silk spinners who were consulted by the Imperial Institute considered that the silk, after having been degummed, would be worth rather less than 1*s*. per lb. It is therefore evident that the raw picked silk, containing 18 per cent. of gum, would scarcely realise as much as 9*d*. per lb., and the danger of a fall in prices has also to be borne in mind.

It is therefore impossible to state that the industry would prove remunerative. If the silk nests had to be collected one by one over a very wide area, the cost of

collection would be so great as to render it very unlikely that a reasonable profit could be assured. In view of this fact, it was suggested by the Imperial Institute in 1909 that the Government Entomologist in Uganda should be asked to investigate the question in order to ascertain (1) whether the "domestication" and rearing of the silkworms is practicable; (2) if so, whether large supplies of the nests could be thus obtained; and (3) the price which would be remunerative to the native.

A study of *Anaphe infracta* has now been made by Mr. C. C. Gowdey, the Government Entomologist in Uganda, and a description of the insect and its life-history and habits has been published in the *Bulletin of Entomological Research* (1912, **3**, 269). *Bridelia micrantha*, the chief food-plant of the worm in Uganda, can be grown from seeds or cuttings, but the latter method is preferable. The trees should not be planted more than 6 ft. apart, as the silkworms need to be well shaded. When they are about a year old they are ready to afford the larvæ the necessary nutrition, and nests may be placed on the trees, or egg-masses placed on the leaves. It is essential that the larvæ should not be disturbed during the course of their life.

After the moths have emerged, the outer envelope of the nests should be cut and the nests then allowed to soak in water for about half an hour. If the nests are handled in the dry state they are liable to cause an intense irritation of the skin, owing to the urticating hairs left by the larvæ. The outer envelope should now be removed, the nests again soaked, and the second envelope then removed and separated into its different layers. The nests should again be soaked both before and after removal of the inner parchment-like envelope. All extraneous matter, including the cast skins of the larvæ and pupæ, should now be carefully picked out, and the silk of the envelopes and that of the cocoons should be packed separately.

The Anaphe silkworm does not appear to be attacked by any of the diseases to which the mulberry silkworm is liable, but it is attacked by various parasitic insects in almost every stage of its development. One of the most common of these is an ichneumon fly which passes its

larval period inside the silkworm, destroying the host and utilising the chrysalis as a protection for its own pupal stage. If the rearing of the silkworm is undertaken as a native industry, precautions will have to be taken against these parasites. In this connection Mr. Gowdey points out that if the nests are collected from the trees and placed in houses any parasites can easily be destroyed on emergence, and that if the eggs of the silkworm instead of the nests are used for stocking new plantations the spread of these parasites will be lessened.

THE ECONOMIC RESOURCES OF THE GERMAN COLONIES

I. German East Africa (*continued*)

Agricultural and Forest Products

In the last number of this Bulletin (1914, **12**, 580) a general description of the Protectorate of German East Africa, illustrated by a map, was given, together with a detailed account of its mineral resources. In the present number it is proposed to deal with the principal agricultural and forest products. For convenience of treatment the former are considered under two headings: (1) native production, (2) European production. The information has been obtained largely from the reports published by the German Colonial Office for the years 1910–11, 1911–12, and 1912–13 (reckoning from April 1 to March 31 in each case). Statistics of exports of the chief products are presented mainly in the tables at the end of the article.

For the preparation of this article the Imperial Institute is largely indebted to Mr. A. H. Kirby, B.Sc., Assistant Director of Agriculture, Southern Provinces, Nigeria, who generously devoted a part of his leave in 1914 to this work.

Native Agricultural Production

Copra.—The exports of copra have increased in recent years until 1912, when there was a fall to 4,177 tons, worth £78,152. This decrease was mainly due to (1) an increase in the number of coconuts used as seed, both by Europeans and natives; (2) the greater consumption

of green and ripe nuts as food owing to increasing prosperity; (3) the fact that some plantations have reached an age of decreasing production, whilst the new plantatations have not yet developed sufficiently to make good the deficiency. The chief areas of coconut growing are, as may be expected, the coast districts, viz. Kilwa (with Mafia), Bagamoyo, Pangani, and Mohoro, in order of decreasing importance; although considerable plantations have been made recently in the inland districts of Morogoro, Mohenge, Bismarckburg, and Tabora. In the coast districts that are at present less important for coconut production than those mentioned, the production has begun to more than satisfy the local demands, and the surplus is being exported; it is in large places like Tanga and Dar-es-Salaam, and on the adjoining road tracks, where the demand for the green nuts consumes a considerable proportion of the year's crop.

Efforts are made to increase the production by encouraging the natives to keep their plantations clean, by the distribution of good plants at cost price (or, in the case of the poorer natives, free), and the award of premiums for the destruction of insect pests; the adoption of the last expedient seems to have lessened the mortality of the palms. Improvement in the preparation of the copra has followed the making of concrete drying floors in several places; and the erection of artificial driers was contemplated in 1912.

There is little employment of the coir fibre for ropemaking.

Ground Nuts.—The export of these has increased constantly and rapidly from 1,882 tons, worth £17,214, in 1908, to 5,957 tons, value £63,602, in 1912, nothwithstanding the fact that the inland consumption is so great that the local needs in many districts are not satisfied. The opening up of the country and the improved means of transport are nevertheless increasing quickly the areas of cultivation, and these are the chief causes of the enhanced exports. The expansion of the industry has taken place in spite of unsatisfactory conditions caused by drought in 1911–12, especially in Muansa, which is at present the most

important producing district. It appears that Mohoro and Kilwa are not suitable for ground nut cultivation, because of their coastal climate. In Dodoma, on the contrary, there is encouraging though slow progress; and it seems that the best conditions for the exploitation of this important product exist in the districts in the neighbourhood of the great lakes; encouraging results have been obtained from experiments in Ruanda, and Urundi is not less promising.

Sesame Seed.—The conditions needed for the raising of this product are somewhat the same as for ground nuts, and like these the exports have increased rapidly; in 1908 836 tons, valued at £9,960, were exported, and in 1912 1,844 tons, worth £26,186. The chief place of production is Kilwa, which in 1911–12 produced almost one-third of the total. Sesame is of the greatest importance in the country as a source of edible oil, and all the larger coast towns possess primitive mills, worked by camels, in which it is expressed. The increase of planting, indicated by the continually enhanced exports, has taken place in all districts where it is grown, except in the important cattle district Mpapua, where much "samli" (see p. 122) is available for food. The crop suffers from the drawback in the Protectorate that the yields are very likely to be reduced by rain during the flowering period, and this points to the usefulness of conducting experiments to ascertain the best times for planting sesame in different districts. In the past, interest in the cultivation has been promoted by the distribution of good seed, and there is much room for its extension in the provinces near the great lakes.

Oil Palm.—This important tree only occurs in any quantity in the Tanganyika depression, where its exploitation is seriously interfered with by the prevalence of sleeping sickness: so that any extension in its cultivation in areas where it will probably thrive best is dependent on the success of measures for the destruction of *Glossina*. Palm oil is only produced in any quantity in the districts of Urundi and Ujiji, and of these the latter does not supply the local needs. There is a considerable demand for the

oil on the shores of Lake Tanganyika, and eastwards through Tabora, and under better conditions there is the prospect of a large industry for supplying the wants of these regions alone. There have been small planting experiments in Mahenge, Bagamoyo, and Pangani, which, however, are too recent to give any indication yet as to the profitable nature of the cultivation. In addition, efforts have been made to increase production at Tabora, by distributing seed to the natives and giving instruction in the cultivation of the plant.

Castor Oil Plant.—This is wild in the whole Protectorate, and the oil is obtained by the natives and used for anointing the body. Its cultivation exists to a noteworthy extent in Urundi and Bismarckburg, but only for local needs.

The cultivation of oil-yielding plants, other than those mentioned specially, exists only to a very small extent, the value of the exports of oil from such plants being £43 in 1900, increasing to £49 in 1911.

Beeswax.—Bees are very common in almost all parts of the Protectorate, and the use of honey is generally known. The value of beeswax is regarded variously in different parts of the country: in several districts, such as Mohoro, Ruanda, and Urundi, it is considered to be worthless; whilst in others, such as Wilhelmstal, it is made into candles after an Eastern pattern for local use. The methods of the natives for the production and collecting of wax are of three kinds, according to their advancement: (1) simple robbery of the wild nests, the commonest method; (2) the putting of hollow pieces of wood or other receptacles in likely places for bees to live in; (3) actual bee-keeping. It is of interest that a native association has been formed in Ssongea for the improvement of wax production. A fuller account of this industry in German East Africa will be found in this BULLETIN (1910, **8**, 28).

In 1908, the export of beeswax was as much as 543 tons, worth £58,406, but fell in the next year to 294 tons, worth £32,270, the cause of this decrease being the very wasteful methods of collection, which usually entail the destruction of the bees. In 1912 there was still a reduced output (340 tons), through the large exploitation of former

years, and the destruction of the bees; but the value (£41,453) was proportionally greater, partly because of the increased price of wax in the world's markets and partly, it is claimed, through the enlightenment of the natives regarding methods of collection (chiefly in Mahenge, Iringa, and Tabora), and the avoidance of adulteration (Tabora). Owing, however, to the conservative character of the natives, it is considered that any extension of the production of good wax can only take place slowly.

Cotton.—Since 1908, when the export was 594,328 lb., valued at £12,472, the exports of raw cotton have rapidly increased, until in 1912 they were 4,139,513 lb., worth £105,512. By 1910–11 native cotton growing had progressed chiefly in the districts of Muansa, Bagamoyo, Morogoro, Mohoro, Kilwa, and Lindi, in spite of much damage to the crop in different places, chiefly through unfavourable conditions of weather and insect attack. The demand for seed for planting in that season was very large. In former years it had been impossible to obtain a product of uniform quality, so that lower prices had been the rule; this condition was improved by means of a Government Order to the effect that only one kind of seed should be distributed for planting in each district, the particular kind being determined by the local authority in consultation with the European planters, who buy up most of the native cotton. Such seed could only be distributed by that authority in each case. Many cotton-buying firms will only purchase cotton which has been raised from seed supplied by them.

Much mistrust has existed among native growers in the past, because of the different prices given to them for their produce under various conditions, and the German Colonial Economic Committee of Berlin has tried to mend matters by declaring a guaranteed price for native seed-cotton of about *2d.* to *2½d.* per lb. This attempt to increase the confidence of the native has not met with any great success, for the price was often raised above that guaranteed, by overbidding on the part of private buyers; and, on the other hand, has been lowered by firms already mentioned, who buy only cotton raised from the seed supplied by

them. The ensuring of a definite price for native seed-cotton is one of the most important requirements for the proper development of cotton production in German East Africa. The action of middlemen in not providing means for ascertaining the correct weight of the cotton bought by them has also added to native mistrust, and the Colonial Economic Committee has gone the length of furnishing a large number of hand-balances for weighing the seed-cotton; these were supplied to the local authorities and other trustworthy persons.

Efforts have been made by the administration to improve the quality of the cotton by training the natives in careful methods of picking and grading their crop. In order to make these efforts successful, however, it is essential for the local buyers to discriminate between the grades of cotton they purchase, for if they do not the native regards both the instruction and the preparation of the cotton as unnecessary burdens. The quality of the product has been improved to some extent by the award of bonuses by the Colonial Economic Committee for good cultivation and preparation; these are partly paid in money and partly in farming implements; but this system was only maintained for any length of time in a few districts. The extension of cotton cultivation, more especially in coast districts in the south of the Protectorate, is impeded by the practice of advancing money on the crop.

The amount of seed for planting distributed to the natives during the period under review (1910–11) was 177 tons.

The amount of success obtained by the adoption of some of these measures for the encouragement of cotton growing by the natives is indicated by a review of the conditions reported during the succeeding seasons 1911–12 and 1912–13. By 1911–12 the cultivation was being taken up to an increasing extent by the natives, although its development was unequal in different districts. Good yields were obtained in this season in Muansa, Mohoro, Lindi, and Bukoba (where the cultivation was, however, only experimental), and poor crops, owing to unfavourable weather, in Bagamoyo, Kilwa, and Pangani; from Morogoro

there were many complaints of damage done by pests and diseases. In several districts near the coast, especially Wilhelmstal, Tanga, and a part of Pangani, cotton planting has become increasingly unpopular among the natives, owing to the unsuitability of the crop to these areas. Where, however, the conditions are favourable, the interest of the more intelligent natives was so great that the seed distributed for planting was insufficient in amount; this was the case in Kilwa, in spite of the yields of the previous crops having been poor. The policy of a guaranteed price adopted by the Colonial Economic Committee gave good results in Muansa.

The gradual limitation of cotton growing to districts where the conditions are suitable continued in the next season, 1912-13. It appears that nowhere was the crop imperilled dangerously by diseases or pests; the returns were good, except for a few local failures. No need was found for insisting on the price-guarantee, as close surveillance by the administration appears to have ensured generally the payment of fair prices. The interest of the natives in the crop increased, and the amount of selected seed distributed was more than half as much again as that of the previous season, being 406 tons.

In 1913-14, 396 tons of Nyasaland Upland seed were distributed for sowing in Lindi, Kilwa, Rufiji, and Dar-es-Salaam; 108 tons of Uganda Upland seed to Muansa; 29 tons of Assili to Bagamoyo and Sadani, and 8½ tons of other varieties.

The results of cultivation for several seasons seem to indicate that American Upland kinds of cotton are better suited for native cultivation in German East Africa than are Egyptian kinds; and it is claimed that the Upland more than makes up for its inferior quality, compared with that of the Egyptian, by its greater resistance to diseases and pests, and to unfavourable conditions of weather.

Wild Rubber.—The chief rubber-yielding plants native to German East Africa are *Landolphia Stolzii* and *L. dondeensis*. The former is a vine which occurs commonly in the New Langenburg district, north of the Lake Nyasa, and the latter is a shrubby plant occurring in the southern parts

of the Protectorate. Other wild rubber plants are *Mascarenhasia elastica*, *Landolphia Kirkii*, *L. lucida*, *Clitandra kilimandjarica*, and *Holarrhena microterantha*.

In 1910 the exports of wild rubber amounted to 725,584 lb., valued at £145,147. In 1911, however, the exports fell to nearly half this quantity, the chief causes being apparently the declaration of a forest reserve in Iringa, and the effect of drought in Kilwa, in decreasing the yield from the vines. There was some small recovery in 1912, the quantity and value being 379,938 lb. and £59,298, although during this year there was again some interference from drought, whilst the quantity obtained in some districts was diminished through an order forbidding the collection of root rubber, and by the increased employment of the natives in other industries. Dar-es-Salaam and Kilwa are regarded as places producing good wild rubber in considerable quantity.

Coffee.—The district of greatest importance for native coffee is Bukoba, where a variety of the *Robusta* type is grown, although there has been increasing planting in Moschi; the exports increased from 1,998,993 lb., valued at £44,350, in 1909, to 3,465,906 lb. and £95,168 in 1912; in the latter year, Bukoba supplied 43 per cent. of the exports. The quality of the coffee prepared by natives has improved in recent years, the reported prices of coffee from the Protectorate being 2*d.* per lb. in 1909, 3*d.* in 1910, and 5*d.* in 1911. The native coffee plantations are usually laid out under one-year-old bananas.

Grain Crops.—The native Sorghum millet, called "mtama," holds the first place among grain crops in the Protectorate, and is the foundation of the people's food throughout large districts; in some regions as much as one or two acres per head of the population is planted. The amounts produced exceed the food requirements, and the primitive resources do not permit of storage for any time, so that where the crops cannot be immediately disposed of, the surplus is to a large extent made into a beer called "pombe," which, in so far as it is not drunk locally, is sold together with some of the surplus millet on the caravan routes. In 1912–13 the production was so great

that pombe was often made for consumption as food; but though this contains little alcohol, it is naturally not a hygienic feature of a daily diet. The suggestion has been made that the production of mtama should be still more largely extended, and that it should be exported to European markets to replace partly the Russian "food barley" consumed on the Continent. Such export is rendered possible by the circumstance that the Tanganyika railway runs through some of the chief areas of production of Sorghum millet. Up to the present, it has had such a preponderating internal importance that the variations in the limited exports have no significance; they have been in quantity and value as follows: 1910, 2,041 tons and £7,436; 1911, 170 tons and £1,035; 1912, 1,187 tons and £7,478. Of the last-mentioned quantity, 1,153 tons went to Zanzibar.

Other millets cultivated extensively, but yet of only local importance, are a species of *Pennisetum* called "mawele" and a species of *Eleusine* known as "ulesi." Mawele, which resists drought well, is grown chiefly in Ugogo and Ungoni. Ulesi is planted mainly in Iringa, Moschi, Langenburg, and Bismarckburg; it is especially in favour for making pombe. There is no export of either of these small millets.

Maize is raised chiefly in the districts of Mahenge (three yearly crops), Iringa, Tabora, Dar-es-Salaam, Moschi, Pangani, Bagamoyo, Ujiji, Wilhelmstal, Mpapua, and Moporo. Like those of mtama, the exports of maize fluctuate greatly, because both the grain and the meal are very highly valued by the natives as food; further, maize suffers less than other grain crops from damage by birds, and the meal keeps well. The exports were 579 tons in 1910, 102 tons (value £494) in 1911, increasing to 723 tons (value £2,990) in 1912, partly owing to an extension of the cultivation by Europeans. Preference is given to the kinds of maize that have been grown in the country for many years ("native" maize), over the highly-bred sorts introduced for trial; it has been found that the former suffers less from insect pests and gives a meal with better keeping qualities.

Rice cultivation could be extended greatly on areas that are specially suited to this crop. The exports (with the values) have been recently as follows: 1910, 647 tons (£5,173); 1911, 589 tons (£6,018); 1912, 902 tons (£10,058). These figures do not give any idea of the production, owing to the local consumption and to the importation of considerable quantities of Indian rice. It is claimed that the home-grown rice is more valuable than the Indian; the approximate value of 1 ton of imported (Indian) rice in 1910 and 1911 was £8 16*s*. and £9 17*s*. respectively, whilst the corresponding value of 1 ton of exported rice was £7 19*s*. and £10 1*s*.; that is to say that the selling price of the imported rice, for which there is to be reckoned the cost of transport and the much higher cost of handling, did not much exceed that of the rice raised in the Protectorate in 1910, and was actually less in 1911. The extension of the use of rice by the natives, among whom it has figured chiefly as a luxury, points to increased prosperity, and the increase of the areas of its by no means simple cultivation indicates some progress in agricultural methods. It is noteworthy that, especially among the rice growers of Dar-es-Salaam, there is a kind of associated organisation for work in the fields, which facilitates the cultivation considerably. Much rice has been raised in the Mahenge district and the Luitche plain; in the former, it is the chief crop, and bears twice a year in many flooded lowlands.

Of other cereals, wheat planting in Langenburg had in 1911–12 exceeded that of all other crops; the Mokinya eat almost only wheat bread; the output in that district was about 1,000 tons, of which 35 tons were exported. Recently, oats and rye are apparently becoming acclimatised, but they are as yet being tried only in a small way.

Legumes.—Beans are of chief importance, and, with peas, have been grown chiefly in Urundi, Iringa, Kilwa, Ruanda, and Tabora. There has been no export of peas, but those of white and coloured food beans have been as follows: 1910, 27 tons, worth £139; 1911, 105 tons, worth £630; 1912, 187 tons, worth £2,406. The increased production is due to the greater use of beans by both Europeans

and natives and to the circumstance that they form a remunerative crop that grows well; the proportionately enhanced value in the exports is due to better sorting. There is room for an important extension in the cultivation of beans.

Other legumes, including the pigeon pea (*Cajanus indicus*), are planted usually in small quantities for purely local needs.

Tuberous Plants.—Cassava (mainly a Madagascar kind which is edible raw and in much demand for planting) is the chief among "tuberous" plants; it is mainly produced for local consumption, and the exports have only been small, as follows: 1910, 83 tons, value £279; 1911, 96 tons, value £423; 1912, 131 tons, value £607; Zanzibar is the chief buyer. Bagamoyo district is the largest producer for export, whilst in Tabora there is a large internal trade.

Sweet potatoes are produced simply for local consumption, especially in the coast districts and the central part of the Protectorate; they form in the regions near the lakes and in Ruanda a substantial part of the native food, being especially valued in the latter district, where there is a large production, and in Urundi and Langenburg. Yams and taro are mainly planted in the districts where bananas are grown. English potatoes are cultivated in all the elevated districts of the interior, especially in Iringa, Mahenge, Morogoro, Mpapua, Langenburg, Moschi, and Wilhelmstal, where they are said to thrive well. The exports are small: 1911, 4 tons, value £23; 1912, 7 tons, worth £58.

Bananas.—These form a chief part of the native food in the country between the great lakes, and in the Kilimanjaro district and West Usambara; but though the cultivation has been increasing, the native production has not yet figured in the exports.

Sugar-cane.—The cultivation of the sugar-cane was once an important industry in the hands of the Arabs, using slave labour. The yield is generally favourable and the home markets are active, and it is hoped that by following the methods of the European planters the native industry will be extended, if only gradually. The chief plantings

hitherto have been in Mohoro and Pangani. In the interior, the crop is grown for the production of sugar in Muansa; in Wilhelmstal and Kondoa-Irangi the cane is generally eaten raw or used for making a kind of beer; there has been an increase in its cultivation in Urundi for supplying cane to labourers on the railway. Some reduction in sugar-cane growing has taken place, especially in Wilhelmstal, owing to the importation of cheap molasses from India.

Date Palm.—Date cultivation by natives is increasing. The palms, which at present occur only in Tabora, are owned by Arabs; but these are farmed out to people of Indian origin, who pay a high rent even for single trees.

Cloves.—Trials of this spice on a small scale on Mafia Island have given favourable results, and there should be an encouraging prospect for cloves on an island situated so near to the clove islands of Zanzibar and Pemba. A small plantation exists in Dar-es-Salaam, but attempts to introduce the cultivation into Bukoba have failed.

Peppers.—There are important plantings of peppers in the Protectorate, but the wild red pepper is collected in small quantities almost everywhere, for use by the natives.

Ginger.—This has been cultivated to a small extent in one district—Mahenge.

Tobacco.—This is cultivated in all parts of the country, but insufficiently to cover the wants of the natives. The best qualities of native tobacco, which are in much demand in the interior, are raised in Pangani, Bagamoyo, Morogoro, and Mpapua.

Betel Nuts.—The production of betel nuts is chiefly in Pangani, and there is a good demand in Tanga. The value of the exports in 1911 was £133.

Animal Production.—Figures obtained for the purposes of taxation show that stock-keeping is an important native industry; although it was only the Masai, living in Moschi, who by 1911–12 had brought their herds to the numbers existing before the outbreak of rinderpest in 1892–93. A fresh outbreak of this disease in 1912–13 was controlled by the work of the veterinary staff, but a certain loss through the disorder always occurs. In general, the

primitive custom of having a surplus of male animals exists, leading to neglect of selection and to inbreeding through uncontrolled pairing, although cattle-breeding, in the proper sense of the word, is carried out by the Masai, the Watussi (in Ruanda, Urundi, and Ujiji), and to the smallest extent by the Wahele (in Iringa and Mahenge), and the Wagogo (in Dodoma, Mpapua, and Kilimatinde). The best breeders are the Masai, who by systematic, consistent breeding get the most useful results, producing stud animals which are said to be excellent, fitted for the conditions of the country and suitable for use in breeding by Europeans. The Watussi, equally well known as breeders, aim partly for bigness of horn, withdrawing unlikely animals from the herd. The other races referred to are stated to be quite inferior, as breeders, to the Masai and the Watussi. The official efforts to improve this form of native activity are made more difficult by the aversion of the natives to selling cattle, especially heifers and cows, and the liability to disease owing to the over-stocking of pastures.

Hides are the chief export product of native cattle raising, but they have had little value in the world's markets, owing to the general practice of drying them in full sunlight. There has been improvement recently, however, partly as a result of instruction by the authorities, and partly due to the buying of fresh, unspoiled hides, for subsequent careful treatment, by several large firms.

The preparation of "samli," a clarified butter, is a large native industry; its export is included in the statistics under milk, butter, cheese, eggs, etc. It is produced for export chiefly in Muansa and Shirati. The production in Ruanda is also important, but, for want of transport, it is consumed locally, being used mainly for anointing the body; there is also a good internal trade in Ugogo.

European Agricultural Production

Sisal Hemp.—The cultivation of this plant, started in 1893 by the German East Africa Company with a few plants from Florida, has made rapid progress in spite of the difficulties with which it has had to contend. In 1910–11

there were fifty-four plantations, with 47,625 acres (19,140 bearing); in 1911–12 and 1912–13 the areas were respectively 53,388 acres (28,408 bearing) and 61,878 acres (35,898 bearing).

In 1910–11 the price of the fibre ranged from £28 16*s.* per ton, for the first quality, to £14 18*s.* for the lowest quality. The exports in 1911 were 10,989 tons, valued at £226,612, those for 1912 were 16,738 tons, valued at £367,961; and the trade has continued to increase.

The plant can be grown under widely different conditions of soil and climate, and is therefore not confined to any particular district; the extent of the cultivation has, however, been limited by the means of transport and the water supply. It is noteworthy that in the interior, at a distance from the coast, the plant yields proportionately shorter fibre, with a larger fibre content in the leaves, than in the coastal districts.

The Sisal hemp industry has had to compete against the exploitation of the native Sansevieria (*S. Ehrenbergii* and *S. cylindrica* or *S. sulcata*). These plants grow wild, propagate themselves, and require no attention while growing; their harvesting may be delayed for a considerable time, enabling the leaves to be collected all the year round, and the leaves may be stored for some time before the fibre is extracted.

The Sisal, on the other hand, has to be harvested at a particular time, and the fibre must be extracted from the leaves as soon as they are cut. Sisal has, however, been able to overcome this competition on account of the greater yield of fibre (4 to 4½ per cent. from the fresh leaves of *Agave rigida* var. *sisalana*, as against 3 per cent. from those of *Sansevieria Ehrenbergii* or *S. cylindrica*), and also on account of the superior quality of the fibre.

Plantations are as a rule made by means of suckers. The rate of growth depends upon the richness of the soil. On rich soils the plants are ready for cutting after about eighteen months, and continue to yield leaves for about three years. On less fertile soils, the leaves do not reach maturity till three years after planting, but the length of life of the plant is proportionately longer, and it continues

to yield leaves for from five to seven years. On poor soils the rate of growth is even slower, and the length of life longer. In general, on soils of any quality, a plant yields, during its life, about 200 leaves for fibre extraction. Further details as to Sisal hemp cultivation in German East Africa will be found in this BULLETIN (1913, **11**, 141).

Reference may be made here to a bacterial attack to which Sisal hemp is subject, which causes the hemp, quite white when exported, to contain fibres of a red colour on arrival at Hamburg.

To combat this attack, the disinfection of the water used for washing the fibre has been recommended.

Cotton.—In 1910–11 cotton was making progress as an unmixed cultivation under European management; there were 165 plantations with 21,795 acres as unmixed culture, and 13,306 acres with cotton between rubber or Sisal. Steam ploughs and manures were used to some extent, and the kinds of cotton sown were mainly Egyptian. The damage from pests and diseases varied according to the locality; the chief disease was leaf-curl; but the prices and value of the Egyptian cotton were generally good. Caravonica cotton had been grown, but was failing chiefly in Wilhelmstal, Morogoro, and Kilwa; it was found to suffer much from pests, and had only been successful so far on a large scale in Muansa; on a large Government experimental area in Morogoro it developed a pest new to cotton, and the plants had to be burnt in order to protect neighbouring plantations.

There was a small increase in the acreage of cotton in 1911–12, to 35,770; in this season there was much loss from pests and diseases, especially from leaf-curl, and in addition drought and untimely rain at ripening destroyed a large part of the crop in many places; the damage was especially great in the case of Egyptian kinds, and indicated the desirability of its replacement by Upland; this is in agreement with experience elsewhere in Africa. The cultivation by Europeans existed at this time, to a noteworthy extent, only in Mohoro, Kilwa, Lindi, Morogoro, and Muansa. Experience was leading to the conclusion that cotton cultivation is not suited to some of the northern districts, chiefly

owing to climatic conditions. Where these conditions are not unfavourable, the chief matter is to choose suitable soils, and in this connection it is not to be gainsaid that the desire to reduce the cost of cultivation, through the trust placed in modern farming implements, has led the planters to take up for cotton cultivation many soils unfitted for it, among such being the heavy soils of the high grass lands and savannahs, where the freedom from trees or the small stands of plants like acacia tempt exploitation. On such lands the poor state of the cotton is in striking contrast to the condition of this crop on neighbouring native lands with lighter soils and cultivated with the hoe; although the natives themselves by no means choose always the best lands. Another cause of poor yields is the general want of a proper rotation of crops. What are greatly wanted are pest- and disease-resisting kinds with a short vegetative period.

By the next season, 1912-13, Upland cotton, especially Nyasaland Upland, seems to have established a superiority over the Egyptian; and was often substituted for it, especially in Morogoro. Progress was being made, particularly in the proper choice of soils and in the methods of cultivation, and the suggestion has been made that one of the best means for the continuation of this progress would be the centralisation of the trade and the creation of a standard market for cotton from the Colony.

Kapok.—The cultivation of kapok is increasing; the areas (not all bearing plants), and the quantity and value of the exports have been: 1910, 1,735 acres, 12 tons, £652; 1911, 3,458 acres, 28 tons, £1,151; 1912, 6,580 acres, 52 tons, £3,130. The natives participate very largely in the production, and there is a large employment in the Protectorate of the fibre for stuffing cushions and mattresses.

Calotropis.—The cultivation of this plant for its floss as a substitute for kapok is still in the experimental stage.

Ramie.—Experiments with ramie have only been carried on to a noteworthy extent in Aruscha.

Silk.—In 1910-11 small trials were being made in Bukoba in the domestication of the native silk-producing insects, *Anaphe* spp. (see p. 105) and 111 acres of *Bridelia*

micrantha, a food plant of the species, had been planted out; this area was extended to 300 acres in the next season. No definite results have so far been published.

A favourable extension from small beginnings of the breeding of the true silkworm (*Bombyx mori*) has been made in Morogoro.

Rubber.—The rubber planting industry in German East Africa has made rapid progress, the value of the exports of plantation rubber, including gutta percha, rising from £20,798 in 1908 to £362,012 in 1912. The Ceara rubber tree (*Manihot Glaziovii*) has been most extensively planted in the Protectorate, although there are also much smaller areas devoted to *Funtumia elastica*, *Hevea brasiliensis*, and *Ficus elastica*. The areas under Funtumia, Hevea, and Ficus only amounted to 355 acres in 1910–11; 698 acres in 1911–12; and 1,035 acres in 1912–13. In Langenburg, a small Landolphia plantation was made some years ago.

With reference to the planting of the Ceara tree, the general cultivation of rubber in the tropics and the rise in price of the product led at first to a considerable extension of the plantations, and in April 1911 there were in the Protectorate 248 rubber plantations with a planted area of 63,222 acres. During 1910–11 the high prices for rubber led to severe tapping of the trees, so that they were usually much damaged, and breakage by the wind was extensive, and for the same reason the plantations were extended hastily, with consequent less thorough cultivation and rise of wages through scarcity of labour. In 1911–12, notwithstanding the fall in prices, the planting was extended, especially in Morogoro and Tanga, and in this season, too, many trees reached a productive age, causing an increase in exports, of which the lessened value was due to the lower market price. The extension of planting continued in this and the next season, in spite of the rubber crisis; the actual area being 81,705 acres in 1911–12, and 112,258 acres in 1912–13. Attempts were made to improve the economic condition of the industry, mainly by means of less expensive methods of tapping and by the utilisation of catch crops or of secondary cultures such as beans and maize.

Coffee.—The chief areas under coffee are situated in Wilhelmstal, Moschi, Aruscha, Bukoba, and Langenburg; and in all these places there has been a significant increase of planting, together with an improvement in the preparation. It is stated that there has been an effort on the part of discerning planters to create a standard mark for coffee from the Protectorate, so as to enhance its value and cause this to be recognised in the trade. The areas planted in coffee have extended as follows: 1910–11, 6,108 acres; 1911–12, 7,260 acres; 1912–13, 12,008 acres.

Cocoa.—This crop is only cultivated on a small scale; the areas were: 1911–12, 250 acres (125 bearing); 1912–13, 300 acres (175 bearing).

Sugar-cane.—In 1911–12 sugar-cane cultivation by Europeans seemed to have taken on a new activity. The areas were very small: 90 acres (Pangani and Mohoro) in that period, and 345 acres in 1912–13.

Bananas.—The cultivation is of no great importance; in 1912–13 the area in European plantations was 388 acres, and the export of bananas and banana meal amounted to 7 tons. Any recent extension has taken place in Moschi and Wilhelmstal.

Grain Crops.—Maize and mtama are grown for feeding plantation labourers, and have been planted lately in competition with the native produce. The production of maize by Europeans for export has not yet taken place, owing to the heavy cost of transport; there is said, however, to be great scope for its extension; in 1912–13 the plantation area was 9,475 acres.

The rice planted by Europeans in Lindi in 1911–12 was 520 acres; this was successful, and its cultivation has been begun in Pangani. The damage to the crop by birds has been reduced by planting long-bearded kinds. By 1912–13 the area had increased to 1,165 acres, and there were very good prospects for its large extension.

In the more elevated parts of the Protectorate, Europeans grow wheat, oats, barley, and rye to a very limited extent for their own needs. Wheat suffers much from rust and from depredations by birds; a rust-resisting kind imported by the Government is said to have proved good.

Legumes.—There seem to be very good prospects for a much-extended cultivation of beans; by 1912–13, bean cultivation had advanced from a secondary position in the agriculture of the Protectorate to a carefully fostered branch of industry. A white food bean, which commands a good price in the markets, is in much favour for planting. Large extensions of the areas in both white and coloured beans have taken place principally in Wilhelmstal, Moschi, and Morogoro. It is realised that legumes come into consideration for rotations, especially with cotton.

Tuberous Plants.—The cultivation of the English potato in the high-lying districts has extended until it has become an article of export, although to a very small degree; two crops a year have been obtained in Wilhelmstal, Moschi, and Morogoro. Other European vegetables are grown for local consumption and for sale in large towns and the chief ports. Cassava is planted for feeding labourers and for pig raising.

Fruits.—These are cultivated from place to place throughout the whole Protectorate, for the owner's needs and the local trade. Those grown in the West Usambara include apples, quince, apricots, peaches, cherries, and grapes.

Spices.—A small total area of 175 acres of pepper gives good results. In Mafia island a few experimental areas have been planted with cloves by Europeans.

Tobacco.—Activity has been concerned with experiments in the production of Turkish cigarette tobacco, in Kibongoto by the Government and in Moschi, Wilhelmstal, and Langenburg by planters. These have given no definite results, chiefly because of difficulties in the curing and fermentation.

Oil-yielding Plants.—The plantation of the coconut palm by Europeans has begun in Dar-es-Salaam, Mafia, Morogoro, Tanga, and Wilhelmstal, the number of the trees being about 784,500 in 1912–13. By this time, some of the planters had contemplated getting copra driers; and if this was done it would doubtless afford a useful means of instructing the natives in the proper preparation of copra. Owing to the time that coconut plantings take

to come into remunerative bearing, there is a tendency to put money into existing plantations, thus leading to the extension of these rather than the planting of new areas; in this way large plantations have come into existence near the larger towns such as Dar-es-Salaam and Tanga.

Regarding other oil-yielding plants, there is some European activity with respect to oil palms, and experiments with the sunflower have been begun on a large scale.

Animal Production.—In 1912–13 the number of cattle possessed by Europeans was over 43,500, as far as was shown by returns. The improvement by breeding has been made more difficult by the unwillingness of the natives to sell their cattle; and it has largely failed in the past through the crossing of unselected native cattle with beasts imported from Europe without reference to the fitness of the latter for the country or the conditions that they will have to face. Experience indicates that the best results would be obtained by selection from the herds of the Masai and the Wahele, improvement of these by controlled breeding among themselves, and then cross-breeding with suitable cattle from Europe. The native cattle appear to be docile, and to withstand unfavourable conditions; and the European breeds imported for crossing with these should possess similar characters to those of the native as regards simplicity of needs, power of resistance, and size, together with a higher production of meat and milk. Favourable results have been obtained in Sadani (Bagamoyo) by crossing good native cattle with bulls from the Campagna.

The best conditions for horse-breeding appear to be in Iringa; the production of asses and mules is only small. Most of the trials in the breeding of woolly sheep have failed, partly from want of experience, and partly owing to unfavourable climatic and pasture conditions of the localities concerned; experiments with imported goats failed completely. Pigs breed freely in all the high-lying districts.

There are very good prospects for the production of East African ostriches, especially in Aruscha and Moschi;

but little has been done so far, from want of experience. Good results have been obtained with European and native fowls, although constant losses occur among the European breeds from diphtheria.

Of diseases among stock, malignant catarrhal fever causes much loss among native stock; no good remedy for the disease appears to have been found, but it may be prevented to some extent by isolation. Rinderpest has shown itself among European stock in Kilimanjaro (apparently introduced from Shirati), Umbulu (apparently from Muansa), and Ugogo (from the Masai reservation); the losses were much reduced by inoculation, combined with the strict prohibition of movement of cattle and the isolation of affected animals. The chief epidemic areas of coast fever seem to have been Langenburg, Ruanda, and Mangati; the incidence of this disease has been generally decreased by the isolation of pastures and the systematic changing of feeding grounds: European cattle suffering from it quickly respond favourably to the latter measure. Splenetic fever has increased in Ussangu and Iringa; it is endemic in Ruanda. The diseases carried by tsetse naturally show themselves chiefly in imported animals, but they have been largely lessened among those in transit in the country by sending the animals by rail and by avoiding the fly belts as far as possible. Horse-sickness appears every year during April to July in Dar-es-Salaam, Tanga, Moschi, Aruscha, and Muansa; it shows itself sometimes as early as March, such early appearances being correlated with an early setting in of the chief rainy season; investigations have shown so far that West Usambara, Ngorongoro, and the highlands of Iringa and Langenburg are free from the disease, so that they come into special consideration as areas for horse-breeding.

Scab has caused much loss among native sheep and goats in Iringa and Kondoa-Irangi; it was also found among woolly sheep in Aruscha; the disease has existed also to a noteworthy degree among goats in Dar-es-Salaam, Iringa, Tanga, and Wilhelmstal. Infectious pneumonia of goats has prevailed in some parts of Kondoa-Irangi and Pangani.

The importation of animals from Germany has been under strict control; horsekind, especially mules, have been obtained from Aden. In the overseas exchange of animals, a curious fact was found in that native goats imported into Germany (from Mpapua, Kilossa, and Amani) largely died there from a disease said to be unknown before—catarrhal fever of goats; native (German) goats allowed among these suffered little or not at all, indicating their immunity. This is of general interest and importance in that it suggests the latent existence in temperate climates of diseases to which the native living beings (including the human) are immune.

Forestry

The most important timber forests in the Protectorate are situated in the Usambara highlands and along the lower course of the Rufiji, while mangrove forests occur along the shore in many parts. Forest reserves have been created, particularly in the coastal districts, and these are under the control of a Government Forestry Department. From 1910 to 1913 the numbers and areas of the forest reserves were as follows: 1910 (beginning), 93 with 955,140 acres; 1910 to 1911, 129 with 1,069,120 acres; 1911 (end), 1,211,045 acres (about 0·5 per cent. of the total area of the country); 1912 to 1913, an increase from 161 reserves with the area just mentioned to 200 with 1,855,268 acres (about 0·75 per cent. of the total area).

The chief measures of protection are concerned with preventing forest fires and unauthorised pasturing; the attitude of the natives is said to be good, and the purpose of the reserve seems often to be understood by them. As *Manihot Glaziovii* has been observed in nature to be a protection against penetration by fire, it has been planted extensively in the fire traces; but time has not yet shown whether or not this measure is of practical utility. New forest plantings have suffered much from fire; but, as in the case of natural growths, the young plants grow quickly when they are protected.

In 1910–11 there were 16,253 acres of mangrove under exploitation, chiefly in Kilwa-Kisiwani, Samanga, and

Kiswere, and later in Kiperle and the Rovuma delta. The richest mangrove bark is derived from *Rhizophora mucronata*, which may contain as much as 48·0 per cent. of tannin. Other valuable mangroves are *Bruguiera gymnorrhiza*, *Ceriops candolleana*, and *Xylocarpus granatum*. Wattle barks (*Acacia decurrens* and *A. mollissima*) are cultivated extensively in West Usambara; the district is well suited to the trees, and the bark produced compares favourably with that exported from Natal and Australia. Experimental plantations of mallet bark (*Eucalyptus occidentalis*) and divi divi (*Caesalpinia coriaria*) have also been made. The total value of tanning bark exported in 1912 amounted to £4,992.

Timber cutting is done chiefly in the Rufiji delta, Wilhelmstal, Tanga, Pangani, and Kilwa-Kisiwani. The chief timbers cut in the Wiese forest in West Usambara (Wilhelmstal District) are pencil cedar (*Juniperus procera*), Outeniqua yellow-wood (*Podocarpus gracilior*), and common East African yellow-wood (*Podocarpus Thunbergii* var. *milanjianus*). The two last-named both come on the German market under the name of "East African pine." Among hardwood timbers cut in the Usambara forests and utilised chiefly in the native school of carpentry at Tanga are *Chlorophora excelsa*, *Khaya senegalensis*, and *Cephalosphora usambarensis*. Experimental plantations of timber trees have been laid out in most of the Administrative Districts. They include teak, *Eucalyptus resinifera*, *E. globulus*, box, *Juniperus virginiana*, and *J. bermudiana*. The total value of the wood, timber, and charcoal exported in 1911 amounted to £25,950, and in 1912 to £11,857.

The exploitation of wild rubber has already been referred to (p. 116). It has been collected chiefly in the forest reserves of Kimboza, Mouha, Uluguru (Morogoro), and Unguru (Bagamoyo).

Camphor (*Cinnamomum Camphora*) and cinchona have been cultivated experimentally at Amani with promising results.

The following table shows the quantities and values of the chief exports from the Protectorate in 1911 and 1912:

Product.	1911.		1912.		Chief countries of destination in 1912.
	Tons.	£	*Tons.*	£	
Maize	102	494	723	2,990	Zanzibar.
Rice	589	6,018	902	10,058	Other parts of the mainland.
Sorghum (mtama) . .	170	1,035	1,187	7,478	Zanzibar.
Other cereals . .	66	463	141	834	Zanzibar and other parts of the mainland.
Legumes . . .	105	630	187	2,406	Germany and Zanzibar.
Tuberous plants and vegetables	127	756	191	1,492	Zanzibar.
Bananas, dried bananas, and banana meal	¾	10	7	216	Germany.
Coconuts . . .	63	165	27	94	Germany and Zanzibar.
Fruits, fresh and dried .	2	32	5	95	Other parts of the mainland.
Coffee	1,153	63,302	1,544	95,168	Germany, other parts of the mainland, and the United Kingdom.
Cocoa	8	533	12	699	Germany.
Peppers of all kinds .	24	727	18	453	Germany.
Sugar, raw and refined .	17	243	25	381	Other parts of the mainland.
Syrup and molasses .	210	1,679	62	580	Zanzibar.
Tobacco . . .	28	975	36	1,244	Zanzibar.
Copra	5,312	92,249	4,173	78,152	Zanzibar, Germany and other parts of Europe.
Ground nuts . . .	2,455	24,487	5,957	63,602	Germany and other parts of the mainland.
Sesame	1,603	20,191	1,844	26,186	Zanzibar and Germany.
Seeds and cuttings; fodder plants	1,229	6,703	2,485	12,211	Germany.
Raw cotton . . .	1,059	66,591	1,844	105,512	Germany.
Kapok	28	1,151	52	3,130	Germany.
Sisal hemp . . .	10,989	226,612	16,738	367,961	Germany.
Coconut fibre and similar fibres	84	458	87	519	Zanzibar and Germany.
Woods, timber and charcoal	6,388	25,940	3,893	11,857	Germany and Zanzibar.
Tanning woods and barks	1,862	4,793	2,445	4,992	Germany.
Rubber and guttapercha, plantation	671	180,480	998	362,012	Germany and United Kingdom.
Rubber and guttapercha, wild	168	58,568	181	59,298	Germany.
Live animals . . .	—	3,460	—	2,183	Germany and Zanzibar.
Dairy produce . .	294	9,355	324	12,888	Other parts of the mainland, Zanzibar, and India.
Ivory	25	24,270	17	18,056	Zanzibar and United Kingdom.
Hides and skins . .	2,478	151,759	2,885	203,368	Other parts of the mainland, Germany, and United Kingdom.
Wax	357	40,846	340	41,453	Germany, other parts of Europe, and other parts of the mainland.
Mica	96	17,414	151	24,075	Germany.
Copal	93	5,370	106	5,986	Zanzibar, Germany, and United Kingdom.
Gold	—	—	—	26,531	Germany.
Gold ore . . .	—	51,172	—	—	Germany.
TOTAL EXPORTS .	—	1,121,888	—	1,570,919	—
TOTAL TRADE (imports and exports)	—	3,416,470	—	4,086,377	—

Percentage of the above Exports over Inland Boundaries, where this is Notable

Product.	1911.	1912.
Grain products	67	34
Coffee	47	43
Sugar, raw and refined	63	89
Ground nuts	79	86
Raw cotton	18	21
Wild rubber	11	6
Milk, butter (samli), cheese, eggs, etc.	91	87
Hides and skins	79	72
Wax	35	14

NOTES

Philippine Fibre Industry: Introduction of a Compulsory Grading System.—During the last decade certain changes have taken place in connection with the production and grading of Manila hemp (abacá) which have caused a deterioration in the quality of the fibre, and have tended to lower the status of the industry both in the Philippines and in the markets of the world. The situation ultimately became so serious that the Government considered it necessary to establish a system for regulating the industry. A Fibre Grading Law was therefore enacted in 1914, and a series of regulations was subsequently authorised under it.

A copy of this new legislation, and a discussion of the causes which led to its introduction and the benefits to be derived from it, are given in the *Philippine Agricultural Review* (1914, **7**, 371), and are supplemented by a description of the new standard grades and an article on the methods of rejuvenating depleted abacá fields.

The following are the causes which have led to the decline of the industry. A considerable increase has taken place in the number of grading and baling establishments, until at the present time over ninety are in operation. About eight or nine years ago the grading and baling were done almost entirely by a few large and reliable firms who were in constant touch with the market and its requirements, whereas these firms now handle only about 10–15 per cent. of the fibre, the remainder being graded and baled in provincial establishments which lack uniformity in their methods and are not properly acquainted with the needs of the market. Partly as a consequence of this multiplication of baling establishments, the number of grades has been greatly increased, some of them being designated merely by the marks of the grading houses. This has led to great confusion, both amongst the producers, who can no longer

recognise the exact quality of their product, and also amongst the purchasers, who are placed in the difficult position of not knowing what quality they will receive when ordering certain grades or marks. The ignorance of producers as to the actual quality and value of their product, due to this increase in the number and designation of grades, enabled local buyers to profit by purchasing the better classes of fibre at less than their real value. As a result, the producers found that they were paid a relatively higher price for the lower grades than for the higher, and therefore they devoted their efforts to the production of the former. In some cases, they have resorted to sophistication by mixing inferior fibre or "pacol" (the product of the wild banana) with the higher grades, or by packing the material while it is still wet.

The decline in the quality of the fibre which has been thus brought about has had serious results. The markets are being flooded with large quantities of undesirable material which manufacturers utilise for mixing with better grades, with the consequence that the reputation of Manila hemp has been injuriously affected, and an opportunity has been afforded for other cordage fibres, especially East African Sisal hemp, to enter into serious competition with it.

The situation has become aggravated by the fact that most of the smaller producers in the Philippines, as a result of producing low and coarse grades, have been earning barely sufficient to supply the necessaries of life and are unable to carry out any improvements on their plantations. The condition of the plantations has therefore greatly deteriorated, and the industry has thus been gravely injured at the source of production.

In view of this alarming state of affairs, the Philippine Government decided that it was necessary that immediate action should be taken to save the industry from disaster, and to establish such conditions as would enable it to regain its former prosperity.

The Fibre Grading Law and the regulations put in force under it have been designed to remedy each of the defects referred to above. A fixed official standard of grades has been established, standard specimens must be obtained by every grading house, and the grades of each establishment must conform with the corresponding official grades. The fibre must not be baled unless it is thoroughly dry, adulteration of every kind is prohibited, and baling and labelling must be carried out in accordance with particular instructions. Every grading establishment must obtain a special licence to carry on its work and must at all times be open to official inspection. In order to arrest the deterioration of the plantations, inspectors have been appointed and an educational campaign among producers

has been organised. The object of this campaign is to afford the producers a knowledge of the different grades and their respective values, and to give them the instruction necessary to enable them to improve their plantations and the quality of their product.

The Grading Law and regulations apply not only to Manila hemp but also to "Maguey" (the fibre of *Agave Cantala*) and to Sisal hemp (the fibre of *A. sisalana*). Standard grades have been established for (1) Manila hemp (well-cleaned fibre), (2) Manila hemp strips (partially cleaned fibre), (3) Maguey and Sisal (retted), (4) Maguey and Sisal (knife- or machine-cleaned), and (5) pacol or wild banana. The grades of Manila hemp (1) and the letters by which they are designated are: Extra prime, A; prime, B; superior current, C; good current, D; midway, E; current, F; seconds, G; brown, H; and damaged, strings, and tow. Manila hemp strips (2) are graded into fair, medium, coarse, and coarse brown. Three grades of Maguey and Sisal (retted) are recognised—viz. Mgy or Ssl 1, Mgy or Ssl 2, and Mgy or Ssl 3, and those of the knife- or machine-cleaned fibre are Mgy or Ssl, good, A; Mgy or Ssl, fair, B; and Mgy or Ssl, common, C. Pacol is classed as PCL1, the well-cleaned fibre; and PCL2, strips or partially cleaned fibre.

With regard to the condition of the Manila hemp or abacá fields, it is pointed out that no real system of cultivation prevails. The grass and weeds are occasionally cut with the "bolo," and dead plants are replaced by transplanting a few single plants to the vacant spots, but such planting is carried out unsystematically and too closely. The plantations are neither ploughed nor manured, and no rotation of crops is practised. The older plantations, therefore, yield much less fibre than those more recently planted. The following methods are recommended for the renovation of such plantations:

Old abacá plants and all trees and bushes should be dug up and removed. The field should then be ploughed at least three times to a depth of not less than 8 in., and afterwards harrowed once or twice in order to smooth it. The abacá is best grown from rootstocks, which should be planted at, or a little before, the commencement of the rainy season. Cowpeas should be sown broadcast and rather thickly before planting the abacá if possible, but if the abacá is planted first the cowpeas should not be sown until the latter has come up. The cowpeas mature in about three to three and a half months, and after the seed has been harvested the plants are ploughed in to serve as a green manure. A second crop of cowpeas is then planted and the plants are again ploughed in as before. This process should be continued for a period of fourteen to eighteen months.

The effect of this preliminary treatment is to prepare the plantation thoroughly and free it from weeds, to enrich the soil in respect of nitrogen, and to improve its physical condition by making it light and friable. After eighteen months the abacá plants will have attained a considerable height, and cultivation may now be discontinued until three or four crops of fibre have been obtained. The harvesting of the stalks allows the sunshine to reach the soil, and it again becomes necessary to prevent the growth of weeds by the use of the plough or the hoe.

It is emphasised that these methods for rejuvenating the plantations demand absolutely clean preliminary cultivation, and depend for their success on the proper use of cowpeas.

Coorg Sandalwood.—In the *Indian Trade Journal* for January 14 last (p. 53) a statement is quoted from the *Report* of Forest Administration in Coorg for 1913–14 to the effect that delay on the part of the Imperial Institute in selling a consignment of Coorg sandalwood in London resulted in a comparatively poor price being obtained. This assertion is not in accordance with the facts. The delay which occurred was entirely due to the faulty arrangements made in India. No co-operation between the shipper and the Imperial Institute was arranged. The first notification of the arrival of the wood in London was only received at the Imperial Institute on February 28, 1914, which was obviously too late to enable the wood to be sold by the brokers in February, as it should have been.

Timber for Pit Props.—On the outbreak of war the supplies of pit wood received from the Baltic for the coal mines of the United Kingdom were largely curtailed, and the Board of Trade accordingly took steps to enquire into other sources of supply and to stimulate supplies therefrom. The importance of the question is indicated by the fact that in 1913 the imports of pit wood into the United Kingdom were nearly 3½ million loads, valued at close on £4,500,000. In addition, from 700,000 to 800,000 tons of home-grown timber were utilised, making a total annual consumption of about 4½ million tons. Through the good offices of the French Government the supply from France was not only maintained but considerably increased. Increased supplies also became available from Norway, Spain, and Portugal. A commission of enquiry, dispatched by the Board of Trade to Canada and Newfoundland, reported ([Cd. 7728], 1914) that plentiful supplies of suitable timber were available in those Dominions, and could be placed upon the market in the United Kingdom at a price which would not be unreasonable under the prevailing conditions. In Newfoundland very large areas of fir and spruce exist convenient for shipment. The railway also

passes through other suitable timber areas, affording a means of conveying the timber to shipping points. Labour is available during the winter months, the period during which the timber would be cut and transported. By a special Act the Government of Newfoundland have sanctioned the export of timber free of tax until December 1915, a concession which might be extended if a pit timber industry is established. Newfoundland therefore affords a suitable field of operations.

In Cape Breton and Nova Scotia also large areas of fir and spruce exist within easy reach of shipping ports, and immediate supplies are available at $\frac{3}{5}d$. per lineal foot alongside steamer for timber 3 in. to 7 in. top diameter, in 5 ft. to 9 ft. lengths; and at $2\frac{3}{4}d$. for timber 8 in. top diameter and upwards, 9 ft. to 20 ft. lengths. Cutting of timber has been carried on for many years for the local collieries. In New Brunswick and Quebec immense areas of fir and spruce exist, but the lumber and pulp markets of Quebec and the United States afford at present a ready market for the timber produced. The estimated c.i.f. prices in the United Kingdom for Baltic and Newfoundland timber compare as follows: for Baltic timber, 71*s.* per fathom; for Newfoundland timber (*a*) Bonavista Bay 99*s.* 2*d.*, (*b*) Placentia Bay 120*s.* 3*d.* The Newfoundland prices are admittedly calculated on a high scale.

The bulk of timber used in coal mining consists of poles, $2\frac{1}{2}$ to 7 in. in diameter at the small end, which are cut into convenient lengths for use as pit props. Home-grown mine timber consists chiefly of larch, spruce, and Scots pine, either grown in districts near the collieries, or obtained from Ireland and the Highlands of Scotland. In the urgent necessity created by the war, the supply of native pit timber can be greatly increased for one or two years. Afforestation in Scotland is the chief subject in the *Transactions of the Royal Scottish Arboricultural Society*, Vol. xxviii., Part II. As an example of what can be done in a short period of years, the Benmore plantations on the Clyde are remarkable. Here 2,000 acres were planted thirty-four years ago, mostly on steep and rocky hill-sides, from sea-level to 1,200 ft. altitude, the soil being a poor sandy peat covered with heather. The species cultivated are mainly Douglas fir, larch, *Thuya gigantea*, Scots pine, and spruce; and the average volume per acre is about 3,400 cubic ft., *i.e.* an annual yield of 100 cubic ft. of timber.

A *Report* on the supplies of home-grown pit wood in England and Wales, issued by the Board of Agriculture ([Cd. 7729], 1914), estimates that "extraordinary" fellings would provide a year's supply of pit wood in England and Wales, and that the United Kingdom holds one and a half year's supply.

A pamphlet on "Timber for Pit-props," issued by the English Forestry Association, states that there is an unlimited demand for native larch and Scots pine in one or other of the coalfields. There is a large demand also in some districts for spruce and oak poles, the price being usually fixed by that of the foreign supplies. There is a very large demand in South Wales and some other districts for coppice and inferior timber, but the price is low; also for converted English timber, especially larch, Scots pine, elm, etc., for trams, sleepers, etc. Almost any variety of conifer can find an outlet somewhere, provided the minimum dimensions are 2 ft. in length and 3 in. in diameter. The most important qualification of a pit prop for uprights is straightness.

Kauri Gum.—Under the title of *Kauri Gum Reserves in the Auckland Land District*, the Report has been issued of the Commission appointed in 1914 by the Governor of New Zealand to inspect and classify the kauri gum reserves in the Land District of Auckland, and in particular to ascertain (*a*) which reserves contain or yield sufficient gum to justify their retention as reserves, (*b*) which reserves are sufficiently exhausted of gum to justify the removal of the reservation and the opening of the land for settlement purposes. The work of the Commission involved the inspection of 160 reserves, representing a total area of 228,000 acres, scattered over a wide expanse of country extending from Te Kao, near the North Cape, as far south as Katikati in the Bay of Plenty.

Brief descriptions are given of the kauri gum lands of the Northern Peninsula, together with a short account of the origin of the reserves.

In the early days of settlement in New Zealand the industry was carried on chiefly by the pioneer settlers and small farmers, and by a steadily increasing stream of immigrants from South-Eastern Europe. The latter engaged in gum digging as their regular occupation over the vast areas of unoccupied Crown and other lands, which were then of little value. This influx resulted in an over-production of kauri gum, and a slump in the industry followed, which was very keenly felt by the small settlers and original gum diggers. In 1898, in order to protect the interests of the pioneer gum diggers and to some extent to check this influx, the Kauri Gum Industry Act was passed. As a result gum reserves were established and all gum diggers were required to pay an annual licence fee amounting to five shillings in the case of British subjects and one pound (later increased to two pounds) in the case of aliens. From the passing of this Act up to the present time a total area of 276,210 acres has been set apart as reserves, of which certain areas, amounting in all to 48,849 acres,

have been withdrawn from reservation for various reasons. Most of the land so withdrawn has been selected for settlement.

The total area of the gum-bearing lands (which are all in the Auckland Provincial District) was estimated in 1898 at 814,000 acres. Of this area 435,000 acres were then Crown lands, the balance being represented by privately owned lands and Native lands which had not been adjudicated on by the Native Land Courts. Prior to 1898 there were no restrictions of any kind on the gum diggers. Since that date a certain amount of protective legislation has been introduced, but up to the present time no attempt has been made to prevent gum land from being rendered useless for farming purposes. As a result, the gum diggers have wandered at will over the Crown lands digging holes varying in depth from 3 ft. to 15 ft., and which they are not under any obligation to fill in ; in some cases there are as many as two hundred of such holes to the acre. In addition, the vegetation growing on the lands has been fired year after year by the diggers, and at all seasons. The effect of these successive fires has been to destroy the humus and surface soils, together with gum deposits of very considerable value, while in the case of many peat flats and swamps the fires have gutted them almost to the water level. In contrast to this state of affairs instances are given of private owners who have drained their land and let the gum-digging rights at a substantial royalty on condition that any holes made should be filled in, and all roots, stumps, etc., met with should be thrown up on the surface of the ground, leaving the land in a suitable condition for farming operations. The Commissioners consider that the proper development of the Crown gum lands under judicious management along the lines above described would solve the "unemployed" difficulty for many years to come. The work should prove self-supporting, and the land would be left in a condition suitable for farming. Experiments have shown that gum lands, after breaking in, are suitable for general farming, and certain areas are considered to be well adapted for fruit growing and for afforestation purposes. It is recommended that the lands should be developed by the State before being offered for selection, as the settlement of the gum lands by men possessing little or no capital would probably prove a lengthy process.

The Commissioners recommend that the reservation be uplifted from various kauri gum reserves of a total area of 71,164 acres. A schedule of the individual reserves is given. They are also of opinion that immediate steps should be taken to check the advance of a sand drift which threatens to overwhelm an area of 300,000 acres on the peninsula north of Ahipara. Of this area 100,000 acres are Crown lands including gum reserves. A brief account is also given of

the importance and value of the kauri gum industry. The Commissioners conclude the Report by recommending that a small Department should be created to take charge of the Crown gum lands and the kauri gum industry generally, such a Department to be made self-supporting by imposing an export duty of £1 per ton on kauri gum.

According to the *Chemist and Druggist* (1915, **86**, 111), a Bill amending the law in regard to the kauri gum industry in New Zealand was passed in October 1914. The Prime Minister of New Zealand, in moving the second reading, stated that soon after the outbreak of war gum became unsaleable, and several thousands of men were threatened with unemployment. To obviate this Parliament was asked by the Government for £50,000 to make advances on gum to the extent of not more than 50 per cent. of its value. The kauri would be taken possession of by Government representatives and stored till the market improved. In normal times a large proportion of the gum was exported to Germany for use in the manufacture of varnishes and linoleum. Since the outbreak of war the demand from the United Kingdom had fallen off, but that of the United States was still being maintained. The Premier also stated that the Government intended to work the gum-bearing lands along the lines suggested in the above *Report*, and it was thought that the gum thus obtained would realise more than sufficient to pay the men the current rate of wages.

Prickly Pear: its Destruction and Utilisation.—The plants known as "prickly pears" are members of the cactus family, and include various species of Opuntia. They spread very rapidly, and enormous areas of good agricultural and pastoral land in Queensland and other parts of Australia have been overrun by them and thus rendered useless. Articles on this subject, with special reference to the destruction of the pest or its possible utilisation, have already been published in this BULLETIN (1908, **6**, 314; 1910, **8**, 43).

In 1912 a Commission was appointed by the Queensland Government to visit countries in which prickly pear occurs with a view to ascertaining whether there are any natural enemies of the plant in these countries which could be utilised for its destruction in Queensland, and also to institute enquiries as to the possibility of utilising prickly pear for commercial purposes. The *Report of the Prickly Pear Travelling Commission*, 1*st November*, 1912, *to* 30*th April*, 1914, by T. Harvey Johnston, M.A., D.Sc., F.L.S., and Henry Tryon, has now been published, and contains a great deal of valuable information. An account is given of investigations carried out in Sydney, Java, Singapore, Ceylon, India, South Africa, the Canary Islands, Europe and the Mediterranean area, the United States, Mexico and Central America, the West Indies, South America, and Hawaii.

The Commission recommends the introduction of the following insects into Queensland: *Moneilema* spp., *Coenopaeus palmeri*, *Gerstaeckeria hubbardi*, *Melitara* spp., *Mimorista flavidissimalis*, *Chelidinea* spp., *Narnia* spp., the wild cochineal insects, *Itonida opuntiae*, *Asphondylia opuntiae*, *Zophodia cactorum*, and the "Mendoza moth borer."

Moneilema is a large beetle which is widely distributed in the drier parts of the United States and Mexico; the adult insects feed on the young segments of the prickly pear plant, whilst the larva lives in tunnels which it excavates in the stems and joints. Coenopaeus is a beetle with similar habits occurring in Southern California. *Gerstaeckeria hubbardi* is a cactus insect, the larva of which breeds in the joints of the opuntias; its attacks in Florida are usually associated with those of a very destructive moth, *Melitara prodenialis*. *Mimorista flavidissimalis* is a small pyralid moth, occurring in Southern Texas, which causes great damage to the young segments of the prickly pear. Melitara and Zophodia are very destructive cactus moths; the caterpillars live in the joints of the plant, and cause extensive damage, partly by their own depredations and partly by exposing the tissues to the attack of bacteria, fungi, and scavenging flies. *Melitara* spp. are found in the United States, Mexico, and the West Indies, and *Zophodia* spp. occur in Argentina and Uruguay. Similar injury is caused by the Mendoza moth borer of Argentina. Chelidinea and Narnia are hemipterous insects which attack the joints and fruits respectively; they are found in the United States, Mexico, and the West Indies. The wild cochineal insects have proved very destructive to *Opuntia monacantha* in India and Ceylon. Itonida and Asphondylia are gall midges occurring in the United States; the former produces galls under the areoles which frequently become the seat of secondary infection leading to the destruction of the plant; the latter spends its larval stage in the fruit or flower-bud and destroys the seeds.

It is pointed out that all these insects feed exclusively on cacti, and it is recommended that no insects should be introduced into Queensland which are liable to damage other vegetation in any way.

The Commission suggest that investigations should be carried out in Queensland to ascertain the value of the commoner prickly pear plants of the State for supplementing the various fodders used for stock, and that experiments should be made to determine the suitability of the plants for manurial purposes. They also recommend that investigations should be conducted with a view to discovering whether alcohol could be manufactured profitably from the fruits of the prickly pears, and that paper-making experts should be asked to report on the value of the fibre of the plants for the manufacture of pulp. Reference is

also made to the possible utilisation of the prickly pear as a source of mucilage, oxalic acid, and colouring matter, and for other purposes.

Attention was devoted to the destruction of the pest by overgrowth, by chemical means, and by mechanical methods. The report is illustrated with numerous photographs.

The Utilisation of Raw Mineral Phosphates as Manure.—The term raw mineral phosphate is applied to naturally occurring phosphatic materials which are largely free from organic matter. In this sense the term does not include such substances as Peruvian guano, although it may be extended to embrace guanos such as those of Christmas Island, from which most or all of the nitrogen has been washed out. Mineral phosphates which contain a sufficient amount of phosphoric acid and a low percentage of aluminium and iron are utilised in the manufacture of superphosphate, but in many localities deposits occur which are unsuitable for this purpose, and the question of their utilisation in a raw state as manure is a matter of some importance. Under certain circumstances, too, it may be more convenient to apply the richer materials directly to the land rather than to convert them into superphosphate. To the farmer the matter is of interest, as raw phosphate can usually be purchased at a much lower rate than either basic slag or superphosphate, since most of its phosphorus is classed as insoluble, *i.e.* insoluble in a 2 per cent. solution of citric acid.

Much of the information relating to this subject is not readily accessible to the planter and farmer, and with a view to calling attention to the possibility of employing mineral phosphates as manure, the results of some of the more important experiments in this direction are summarised in the present note.

Raw mineral phosphates may be roughly classified into (1) amorphous or "earthy" calcium phosphate, (2) crystalline calcium phosphate, such as those of Beauval, France, and (3) phosphates of iron and aluminium, such as occur at Redonda. Crystalline calcium phosphates appear to be much less suitable for use as manure than the "earthy" variety. Engelhardt (*Zeits. für landw. Versuch. in Oesterr.* 1900, **3**, 631) states that although he obtained good results by the use of ground amorphous phosphates, the crystalline varieties, as represented by French Beauval and Russian Podolian phosphorites, were of no value as manure.

From a consideration of the literature available, it is evident that finely-ground raw calcium phosphate cannot be applied with equal success to soils of all types. Good results have been obtained on the peat soils of Northern Germany, and it would appear that the amorphous material is most suitable for use on soils of an acid character or

those rich in humus. In some cases results have been recorded indicating that the finely ground raw phosphates (Algerian and Gasfa) may prove even more efficient than basic slag. B. Tacke states (*Hannov. Land und Fort. Zeit.*, 1909, p. 414) that, for manuring soils of the above character, ground phosphate may efficiently replace basic slag, provided that the acidity reaches 0·05 per cent. in the case of cultivated land, and about 0·1 per cent. in that of meadow land. It is recommended that the dressing of phosphate should be about one-fifth greater than when basic slag is used.

On the other hand, there is evidence that raw phosphate, even when finely ground, will often prove of little value when used on a light soil. (See *Report of the Canadian Experimental Farms*, 1910, p. 27.)

It is stated by A. D. Hall (*Fertilisers and Manures*, 1909, p. 156) that "in Britain [finely ground rock phosphates] have proved most effective on wet and peaty soils; they require a soil containing plenty of organic matter to generate a comparatively strong solution of carbon dioxide in the soil water, in which they must become dissolved. For the same reason their action is forwarded by the ploughing in of green crops or by the use of sulphate of ammonia as a source of nitrogen, but on the generality of soils they form but an ineffective source of phosphoric acid."

The fact that the raw phosphates give better results on a soil containing much organic matter has led to the suggestion that their efficiency might be increased by mixing them with decaying organic substances. Pot experiments with Japanese millet (*Panicum crusgalli*), carried out by Hartwell and Pember (*Rhode Island Exp. Agric. Stat. Bull.*, 151), however, indicated that little increase in the availability of the phosphoric acid resulted from treating the finely ground phosphate with cow dung for nine months under various conditions.

The effect of adding raw calcium phosphate to fodder before the latter is fed to animals, in order that it might be acted upon by the digestive juices and so increase its efficiency, has recently been investigated by E. B. Forbes and C. M. Fritz (*Journ. Indust. and Engin. Chem.*, 1914, **6**, 222). Finely ground raw phosphate was added to the silo with the fodder corn; one part of the mineral being used to each 250 parts of ensilage. The experiments indicated that a slight increase took place in the amount of soluble phosphate. Feeding experiments carried out at the Tennessee Agricultural Experiment Station and recorded by C. A. Mooers in *Journ. Indust. and Engin. Chem.* (1914, **6**, 487), showed, however, that when 2 lb. of finely ground rock phosphate were added to each 100 lb. of green ensilage and the mixture fed to cows, after a short time the

animals refused to eat it. The results indicated that a small amount of the soluble phosphate reverted to the insoluble form.

From the results recorded by several observers it would appear that the availability of the phosphorus in raw phosphate rock is not only influenced by the foregoing factors, but also by the nature of the crop grown. This point has been mentioned by D. Prianishnikov (*Landw. Versuchstat.*, 1902, **56**, 107, and 1907, **65**, 23), who concludes that the different solvent powers of the plants are of more importance than differences in the properties of crude phosphates. P. Kossovitch (*Russ. Journ. für Experim. Landw.*, 1909, **10**, 839) states that the utilisation of slightly soluble phosphates varies with the plant, and that the same plant behaves differently towards phosphates of different origins. Recent pot-culture experiments recorded by W. H. Jordan (*Bulletin* 258, *New York Agric. Exp. Stat.*), on the influence of various raw and manufactured phosphatic manures on crops grown in quartz, sandy soil, and quartz with 3 per cent. sphagnum moss, showed that cruciferous crops, such as cabbage and rape, utilised ground Florida phosphate without difficulty. The manure proved of little value with barley, millet, and oats. The experiments also indicated that the fineness of grinding had little influence on the availability of the phosphate in soils deficient in organic matter, but when this constituent was present in good quantity the increase in the quantity of phosphoric acid in the crops of peas, barley, and rape, was proportionate to the fineness of the mineral phosphate.

All the above results and trials are with raw calcium phosphate, and there now remains for discussion the phosphates of aluminium and iron, such as are found in the Islands of Redonda, Grand Connêtable, Sombrero, and Navassa, which contain from 22 to 36 per cent. of phosphoric acid. These phosphates are usually stated to be of considerably less value, for agricultural purposes, than the raw calcium phosphate. Experiments carried out at the Rhode Island College Experiment Station (*Bulletins* 114 and 118) showed that the crop-producing efficiency of these phosphates is considerably increased by roasting and also by the addition of slaked lime when applied to the land. This point is of interest as being contrary to the practice usually adopted in the case of raw calcium phosphate. In some experiments Redonda phosphate has given better results than raw calcium phosphate. Thus Voelcker found (*Journ. Royal Agric. Soc. Eng.*, 1882) that Redonda phosphate gave better results with root crops and cereals than did Cambridge coprolites, and W. H. Jordan has recently recorded that dehydrated (roasted) Redonda phosphate gave better yields than ground Florida phosphate. From the results of other experiments it would seem that phos-

phate of iron is less available than either raw calcium or aluminium phosphate.

The best method of applying raw phosphates would appear to be to incorporate thoroughly the finely ground materials with the soil, as their availability for crop production depends to some extent on the carbon dioxide, acidic matter, and the nitric acid resulting from nitrification in the soil.

The results quoted above indicate that finely ground amorphous calcium phosphate is the most suitable form of raw phosphate for use as a manure. Acid soils and those rich in organic matter are likely to give the best results, and it would appear that cruciferous plants can assimilate raw phosphate much better than cereals.

Egret and Heron Rearing in Madagascar.—In view of the objection that has been raised of late to the destruction of life involved in the supply of egret plumage for millinery, it is interesting to note that in Madagascar it has been found possible to domesticate the egret and obtain its plumage without injury to the bird. An account of this is given in the *Bulletin Économique de Madagascar* (1913, **13**, 472). The author, M. Guilhem, noticed that in the Vohemar province both egrets and herons were to be found reared and tamed by the natives, seeking their food in the marshes or on the cattle in the day but returning to the house to roost at night. They are kept by the natives merely for amusement, no profit being made out of them. The author accordingly started rearing several egrets, and gives the results of his experience. A pair of egrets can be readily reared and kept in a cage of wire trelliswork about 6 ft. long, 3 ft. wide, and 4½ ft. high. They soon become tame and can then be allowed out of their cage, to which they will return for food. They should be fed once or twice a day with scraps of beef or fish cut in long thin pieces, either raw or cooked, but preferably raw. From hatching up to two months they should be given farinaceous food, cooked rice, or meat or fish finely minced. As they grow they can manage larger and larger pieces. A vessel of water large enough for them to bathe in should be provided.

A male and female will live together amicably, and will tolerate their progeny even after they have grown up ; but strange birds in the same cage will fight to death. Perhaps by associating them when quite young this difficulty might be overcome, and a large cage could be used to contain a number of birds. The plumes begin to appear at about six months of age, but should not be taken before sixteen months, or perhaps not until the bird has produced its first brood ; they are finest at breeding time and are cast after this and reappear the next year. They should be removed by cutting near the base, and the stumps should be removed

later when they have dried up. The time to cut them is when the young begin to leave the nest and feed themselves. In commencing to rear them, it is best to take birds two or three months old, as there is then less chance of losses occurring through sudden change of diet.

The species of heron mentioned above, known as the *vorompotsy*, would probably be even easier than the egret to rear, as several could live in the same cage. It is smaller than the egret, and lives almost exclusively on the ticks and parasites of the ox, and thus is a valuable auxiliary to the farmer. Its plumage, though less valuable than that of the egret, would have a certain value, and it would be worth while to make a trial of rearing it at the same time as the egrets.

Norfolk Island.—A most interesting memorandum on Norfolk Island has been furnished to the Minister for External Affairs, Commonwealth of Australia, by the Secretary for the same Department, Mr. Atlee Hunt. The administration of Norfolk Island, which lies in the Pacific 800 miles off the New South Wales coast, and 400 miles from New Zealand, has been vested in the Government of New South Wales since 1896, but the Island has now been annexed to the Government of the Commonwealth. This Memorandum, which is well illustrated with reproductions from photographs and contains a large-scale map of the Island in colours, fills a hitherto existing gap in the literature of the Colonies.

Norfolk Island, about 5 miles long by 3 broad, makes, as described by the Memorandum, a most attractive picture. "Wide areas of well-grassed lands, long avenues and small woods of the stately Norfolk Island pine, broken hills and fertile valleys, the ever present sea with its lines of surf where the long Pacific swell breaks everlastingly on the bases of towering cliffs, the red roads winding in every direction, all clothed in brilliant sunshine, present a succession of spectacles most welcome and restful to the eye of the visitor."

The climate is exceptionally mild, the range of temperature being between 56 and 82 degrees, with a mean of 68 degrees. Notwithstanding the encircling sea and the proximity of the Island to the tropics, the air is not usually humid, except about November. The island in fact is extremely salubrious and has every quality requisite for a health or holiday resort. The Memorandum opines that it will one day become known as the "Madeira of the Pacific." The time from Sydney is 5 days by monthly mail steamer.

Agriculture is the staple occupation. The total area is 8,500 acres, and as the soil is extremely rich throughout, the bulk of this can probably be profitably cultivated, but

at present most of this area is either utilised as pasture or clothed with weeds, the result of allowing once cultivated land to pass into disuse. In convict days there was an able-bodied force of many hundreds, sometimes thousands, of men ploughing and hoeing all the cleared land. But in 1855 the convict settlement was finally removed, not a single person being left behind, and in the following year the whole population of Pitcairn Island was settled on Norfolk Island.

This total new population of 194, which had no necessity for strenuous exertion, was from the labour point of view very inefficient compared with the large previous population, who were of course compelled to undertake productive employment, and though the inhabitants have now increased to 746, the soil is still very casually cultivated. Coffee, fruit, and timber should, the Memorandum points out, all offer openings to the new settler in Norfolk Island. For the ordinary farmer or labourer there is no opening, but "the island does want a limited number of men with a little money and sufficient enterprise and energy to seize the advantages that this rich island offers."

Under the control of the Australian Commonwealth the prosperity of this fertile and inviting spot should be assured, for to those—and they still exist—to whom the conventional resources of civilisation make no strong appeal, the call of Norfolk Island should prove irresistible.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.

Soils and Manures

A considerable area of pasture land in Mid-Somerset known locally as "teart" land, and also a smaller area in Warwickshire, cause scouring in cattle at certain times of the year, with consequent loss to the farmer. An account of an investigation of these lands appears in the *Journ. Agric. Sci.* (1914, **6**, 328). The scouring is most troublesome in the autumn in mild, damp seasons, and the method of dealing with the difficulty is to feed the animals heavily with undecorticated cotton seed cake and to remove them to other land. The complaint is apparently not due to bacterial action, as all attempts to isolate an active organism have failed; further, in many places "teart" and sound

land occur closely intermingled, and yet infection never travels from a "teart" field to a neighbouring sound pasture, nor do cattle transferred from "teart" to sound pastures ever infect healthy cattle with which they come into contact. As a result of the investigation it is concluded that scouring is due to the physiological action of some constituent or constituents of the herbage which are not normally present but only occur under special soil (and weather) conditions; and further that the soil conditions are determined by the texture and can be removed when the texture is appropriately changed.

Investigations have been carried out at the Experiment Station of the Hawaiian Sugar Planters' Association on the question of the influence of fineness upon the availability of bone meal (*Journ. Ind. and Eng. Chem.*, 1914, **6**, 922). The conclusion is drawn that the fineness of bone meal determines the rate at which its nitrogenous constituents will decompose in the soil to ammonia, and also that the solubility of bone phosphate is influenced by bacterial action, and an increased ammonia or nitrate decomposition may be held to indicate a more efficient phosphoric acid solvent action.

Foodstuffs and Fodders

Cocoa.—According to information received from the Governor of the Gold Coast the exports of cocoa from that Colony in 1914 amounted to 52,888 tons, valued at £2,193,749. Compared with 1913 this represents an increase in quantity of 2,334 tons, but a decrease in value of £295,469.

Fruit-growing in British East Africa. — Some "Notes on Fruit-growing in the East Africa Protectorate," by the Chief of the Economic Plant Division of the Department of Agriculture of the Protectorate (*Kew Bulletin*, 1914, p. 268), are of interest to intending settlers. For twenty years attention has been given by settlers to establishing European fruit trees, such as apple, plum, peach, apricot, etc. At the Experimental Stations at Mazeras and Kibos, the introduction, cultivation, and distribution of improved varieties of tropical fruit plants have been carried on, whilst similar attention has been given to temperate and subtropical fruits at the Experimental Farm, Kabete.

Apple-growing cannot at present be regarded as satisfactory. The Avocado pear grows vigorously and produces large crops of fruit at Nairobi. The apricot grows vigorously in the highland districts, but is not a success from a fruiting point of view. Bananas of first-rate quality are grown by the natives. Improved varieties have been obtained from the West Indies, India, and elsewhere, and distributed widely. In view of the attention being given to orange-growing, it seems likely that the Protectorate will

in a few years be able to supply its own requirements, and possibly have a surplus for export. Lemons are thriving around Nairobi, and samples of the fruit have been favourably reported on in Europe. Fine samples of grape fruit have also been produced at Nairobi; samples examined at the Imperial Institute a few years ago were favourably reported on (this BULLETIN, 1911, **9**, 15). The work of the Experimental Farms shows that citrus fruits can be successfully produced over a wide range of country in the Protectorate. The cashew nut grows to a large size, and fruits abundantly in the coastal districts. Several varieties of fig are grown, and generally thrive well in the midlands and most of the settled districts of the uplands. The grape vine has done moderately well in parts of the uplands, but further data are needed to ascertain the localities best suited to grape culture and the varieties to be grown. Mango trees are plentiful in the coast belt and immediate hinterland, and bear heavy crops of fruit. The cultivation of improved varieties of pineapple has been made one of the features of the Experimental Farm at Mazeras with encouraging results.

Production of Vanilla in the French Colonies.—Particulars of the production of vanilla in the French Colonies are given in the *Bulletin de l'Office Colonial, Paris* (1914, **7**, 200). Vanilla is an important crop in Madagascar, but the market is limited, and the island is near other competing centres of production, such as Réunion and the Comoro Islands, the plantations of which are in full bearing and produce a vanilla which is in great repute. Madagascar vanilla is said to be somewhat lacking in aroma. The production of vanilla in Madagascar was largely increased in 1912, the output rising from 52,430 kilos in 1911, to 113,662 kilos in 1912.

Réunion is one of the foremost countries producing vanilla, though the cultivation is decreasing. In the succeeding table it will be observed that Réunion vanilla has the highest value per lb. In the neighbouring island of Bourbon vanilla is grown almost everywhere up to 100 ft. above sea-level; it thrives better, however, in the windward part of the island than in the leeward. Bourbon vanilla ranks in the trade as a vanilla having a strong aroma as compared with Mexican vanilla, the aroma of which is delicate and sweet.

In Tahiti vanilla is grown chiefly by the natives; the pods are picked too soon and their preparation leaves a good deal to be desired; the result is that the produce is sold at a low price, chiefly to Germany and the United States. *V. aromatica* is the species grown.

In Guadeloupe the quantity of vanilla exported has decreased, but the value has increased. Mexican vanilla

(*V. planifolia*) is grown, and also the native vanilla (*V. pompona*) to some extent.

In Martinique the cultivation of vanilla has not spread much and at present remains stationary.

In Gaboon the cultivation of *V. planifolia* has developed gradually during the last fifteen years. Vanilla has often been found wild in both the French and Belgian Congo.

Vanilla is the principal crop in the Comoro archipelago, the greatest quantity being produced in the island of Anjouan, whilst the island of Mohéli gives the best quality. In 1909 the crop amounted to 91,525 lb.

The following table shows the quantities and values of the exports of vanilla from the principal French Colonies in 1912:

From	Kilos.	£
Madagascar	113,662	157,661
Réunion	52,165	64,257
Oceania, including Tahiti and Moorea	187,152	135,070
Guadeloupe	25,148	15,295
Martinique	2,011	2,337
Gaboon	913	1,826

The French Colonies furnish about two-thirds of the world's production of vanilla. France's consumption is about one-tenth of the world's production and averaged between 1907 and 1912 about 60,136 kilograms per annum.

Palm Kernel Cake.—Attention has already been called to the fact that feeding trials with palm kernel cake are being made at various agricultural colleges in this country with a view to making the qualities of this material known to farmers (this BULLETIN, 1914, **12**, 578). The results of one such experiment, in which palm kernel cake was compared with decorticated cotton seed cake as a feeding stuff for milch cows, have been published in *Farmers' Bulletin*, No. 28, 1915, *Agric. Dept., County Council of Lancaster*. Although no definite conclusions can be drawn from the results of a single trial, the results on the whole appear to be quite satisfactory so far as palm kernel cake is concerned. No difficulty was experienced in getting the cows to eat 7½ lb. of the cake per day, provided that it was introduced gradually, and this comparatively large amount had no undesirable effects on the butter produced. The conclusion is reached that palm kernel cake is a perfectly safe food for milch cows. At one time this cake had the reputation in this country of keeping badly, but in the present case it is stated that no difficulty was experienced regarding its keeping qualities, which is probably due to the fact that the cake offered in this country to-day, owing to improved methods of extraction, only contains from 5 to 7 per cent. of oil, as compared with 10 per cent. and over in the cakes available some years ago.

It is worthy of notice that in this trial palm kernel cake is compared with decorticated cotton seed cake. From the point of view of the British farmer a comparison of palm kernel cake with linseed cake would have been more useful. Decorticated cotton seed cake is but little used in this country, whereas linseed cake is the standard British feeding cake.

Oils and Oil Seeds

Castor Seed.—It is suggested that castor seeds might be grown on waste lands in Ceylon, and trials at Ambalantota have yielded very promising results (*Trop. Agriculturist*, 1914, **43**, 277). A scheme for extending its cultivation so as to support a local oil-crushing mill has been proposed, as there is a good demand for castor cake for use as a manure.

Coconuts.—Some interesting mechanical and chemical analyses of the soils and the yields of nuts from trees grown on them in the Federated Malay States have been published by Barrowcliff (*Agric. Bulletin F.M.S.*, 1914, **2**, 333). Native-owned coconuts are found on various types of soil all over the country, but the plantations of European companies are nearly all on the more or less peaty lands of the West coast. When well drained, such soil is excellent, and trees sometimes commence to bear nuts in the fourth year and yield eighty to ninety nuts a year in the eighth or ninth year. These soils are clayey, rich in organic matter, and almost black in colour, and are well supplied with the elements of plant food. If badly drained they are, however, infertile; the drainage need not be so deep as for rubber, as is shown by coconut trees yielding excellently which are growing beside rubber trees which give hardly any yield at all. Inland, coconuts do best on soils of open texture; trees on clay soil only yielding twenty to thirty nuts a year. Sandy soils on the West coast gave poor yields unless heavily manured, although coconuts are reputed to give heavy yields on almost pure sand on the East coast. The clay soils could probably be improved by liming, but the local high price of lime renders its application practically impossible; green manuring with leguminous crops is recommended.

An interesting article has been published by Bamber on the treatment and manuring of the coconut palm. The different soils on which coconuts are grown are described, and the manurial requirements of coconuts are discussed (*Trop. Agriculturist*, 1914, **43**, 191, 276). Young trees respond very readily to cultivation and manuring, and even 80-year-old coconut trees respond, but it is noticed that a large proportion of the increased number of the nuts formed on old trees fall off before they are half-grown. Green manuring with leguminous crops should be particularly useful; "nitrolim" (calcium cyanamide) is said to be the

cheapest form of nitrogenous manure, and as it gives good results with tea and rubber, it would probably be useful with coconuts.

The question of obtaining some return from the land during the first years of a coconut plantation, before the trees commence to bear, is an important one. A Ceylon planter recommends plantains or cassava for this purpose (*Trop. Agriculturist*, 1914, **43**, 388). He estimates the cost of planting and cultivating 1,000 plantain trees for three years at £43, the proceeds of sale of plantains and suckers being £175, leaving a profit of £132. With cassava the cost per acre was estimated at 19*s*. 4*d*., the yield of tubers being 5 to 6 tons, which should bring in £3 7*s*. to £5 per acre according to quality and local conditions. The best month for planting is October, and the tubers should be harvested after eight months, the rest of the plants being cut up, dried, and used as manure.

A number of the more important pests and diseases of the coconut palm are described by Froggatt in *Science Bulletin*, No. 2 (3rd Ed.), *Dept. of Agric. New South Wales*. Attention is paid more particularly to those pests and diseases which occur in Australia and the islands of the Pacific Ocean, but the *Bulletin*, which is well illustrated and contains a useful bibliography, will be of value to all coconut planters.

Ground Nuts.—Owing to the war considerable anxiety as to the disposal of the Coromandel Coast ground nut crop has arisen (*Ind. Tr. Journ.*, 1914, **35**, 187). The normal export of ground nuts from the Coromandel Coast amounts to about 220,000 tons per annum, and most of the crop goes to Marseilles. At the end of August 1914 about 15,000 tons of the last year's crop remained. At that time of the year, too, the small summer crop commences to come on the market, and is followed by the large winter crop in December, but the cultivators had in September been unable to sell their produce to the dealers owing to war conditions. The chief causes of the dislocation of trade are stated to be (1) lack of transport, (2) suspension of the Marseilles market, (3) refusal of British banks to accept bills of lading drawn on French banks.

In view of these difficulties the author discusses the possibility of establishing oil-seed crushing machinery in India on a large scale. He concludes that it would be unwise to attempt this, but points out that small oil-crushing plants may in some cases be suitable. The chief obstacles to the advisability of oil-crushing on a large scale in India appear to be the lack of knowledge of the best methods of producing ground nut oil, the difficulty of finding markets for the oil and oil-cake, and the high cost of barrels for transporting the oil.

The question of finding new markets for ground nuts from India and the British Colonies has been fully dealt with in a circular issued by the Technical Information Bureau of the Imperial Institute, copies of which may be obtained on written application to the Director of the Imperial Institute, South Kensington, S.W.

Oil Palm.—In an article in the *Kew Bulletin* (1914, p. 285) the native names of a large number of varieties of oil palm (see this BULLETIN, 1909, **7**, 357) occurring in British West Africa and other parts of West Africa have been correlated with the scientific varieties established by Prof. Beccari (*L'Agricoltura Coloniale*, 1914, **8**, 5, 108, 201, 255).

Miscellaneous.—Bolton and Jesson have published the results of examination of the following lesser-known oil seeds and oils: *Balanites Maughamii*, *Calophyllum tomentosum* and *C. Inophyllum*, *Melia Azadirachta*, *Fevillea cordifolia*, *Telfairia pedata*, *Canarium luzonicum*, *Schleichera trijuga*, *Sterculia foetida*, *Anacardium occidentale*, *Buchanania latifolia*, *Oenocarpus distichus*, "Marquaqua" nuts (*Analyst*, 1915, **40**, 3). The authors in most cases appear to be unacquainted with previous work on these products, several of which have been examined at the Imperial Institute and also submitted to technical experts for trial (see *Selected Reports from the Scientific and Technical Department, Imperial Institute, Part V.—Oil-Seeds, Oils, Fats, and Waxes*; *Colonial Repts., Miscellaneous*, No. 88 [Cd. 7260], 1914; and this BULLETIN, 1913, **11**, 563, 567). The authors state that the oil of *Schleichera trijuga* might be difficult to detect as a butter adulterant, a statement which might lead readers to think the oil could safely be used for edible purposes. This may be the case, but in view of the fact that the seeds yield prussic acid with great facility, it is desirable to point out that the oil might easily contain this poisonous substance.

According to Jesson (*Kew Bulletin*, 1914, p. 333) a consignment of the seeds of *Osteophloeum platyspermum*, Warb. (*Myristica platysperma*, Spruce), a tree indigenous to North-Western Brazil, was received recently at Liverpool. The seeds consisted of equal proportions of kernel and shell; the latter was brittle and would not be difficult to separate. The kernels contained 55 per cent. of white fat. The quantity of seed available for export is not yet known.

A number of species of *Trichilia* are known to occur in West Africa, and Amman and Vuillet have published the results of examination of seeds obtained in the Nigerian Sudan (*Agron. Colon.*, 1914, **2**, 31). Three varieties, possessing seeds of different sizes and colours, were examined; the large orange seeds resembled those exported from Mozambique as Mafoureira nuts (*T. emetica*) most closely

in appearance and yield of fat; the medium-sized orange-red seeds were from fruits exactly like specimens of *T. Prieureana* at the Kew Museum. Accurate identification of the different varieties was, however, impossible, as the trees were not in flower. It is stated that several hundred tons of Trichilia seeds might be exported annually from French West Africa. The seeds of *T. emetica* from Portuguese East Africa have been examined at the Imperial Institute and the results published in this BULLETIN (1908, **6**, 376).

Babassu nuts (*Attalea* sp.) are stated to be plentiful in the state of Maranham, Brazil, and there is every probability of developing a large export (*Trade of Consular District of Para for* 1913, *Dipl. and Cons. Rep.*, *Ann. Ser.*, No. 5380 [Cd. 7048, 197], p. 24). Coconuts are said also to be plentiful along the coast, but are not yet seriously exploited.

The seeds of a forest climbing plant, *Hodgsonia heteroclita*, yield 59 per cent. of fat known as "Kapayang" oil in Malay, and could probably be utilised if obtainable in quantity (*Bulletin* No. 20. *Dept. Agric. F.M.S.*, p. 37).

Commercial samples of hardened (hydrogenated) oils (see this BULLETIN, 1911, **13**, 660) containing from 0·07 to 6·0 milligrams of nickel per kilogram were fed to animals and human beings for periods up to six months without producing ill effects (*Journ. Soc. Chem. Ind.*, 1914, **33**, 763).

RUBBER

Hevea.—Several papers have been published recently dealing with catch or inter-crops for rubber. Widely different opinions are often expressed as to the advisability of growing catch crops at all, the chief objection advanced being that the soil is likely to become impoverished. According to Macmillan (*India Rubber Journ.*, 1914, **48**, 803) the following products are best adapted for catch crops where rubber trees are widely spaced: tea, cocoa, coca, coconuts, coffee, ipecacuanha, citronella, and lemon grass; pepper and vanilla are suitable for training over fences, shade or boundary trees. As catch crops grown for the first few years, cotton, cassava, chillies, bananas, ground nuts and arrowroot are mentioned; in Sumatra tobacco is commonly grown in this way. Van Hall (*ibid.*, 1914, **48**, 631) recommends Robusta or Quillou coffee where the soil is rich and otherwise suitable for coffee. When planted 6 ft. by 6 ft. the coffee may give a crop in the third year of 390 lb. per acre, and rather more in the fourth year. He recommends removing the coffee in the fifth year. The chief drawbacks of using coffee as a catch crop appear to be that it causes difficulties in the supervision of the estate, necessitates a shed for preparing the coffee, exhausts

the soil, requires more labour, and may harbour pests such as "canker." In some comments on the above paper coffee is objected to as a catch crop, and it is stated that it can only be commercially successful as an inter-crop when grown for many years on good soil between widely spaced Hevea trees (25 to 30 ft. apart). Munro (*ibid.*, 1914, **48**, 669) mentions gambier, castor, indigo, and soy beans in addition to the above-mentioned crops. On account of exhaustion of soil by catch and inter-crops, the increased cost of labour and other disadvantages, he does not think that such crops are advisable as a rule. Bananas, however, have given excellent results, as they reduce the cost of weeding, and form a good mulch for the soil when cut down. The growing of leguminous crops for green manure is recommended.

A description, by M. Barrowcliff, of Malayan rubber soils, appears in the *Agric. Bull. F.M.S.* (1914, **2**, 328). The soils on which rubber is planted in the Federated Malay States may be divided into three classes: those composing the undulating land, rising to a height of 500 ft., that broadens down from the central range of granitic mountains; the flat low-lying land forming the plains and valleys, and formed alluvially from the mountains; and the flat, peaty coast soils, probably fairly recently laid down by the sea, and at the time of reclamation consisting of tidal mangrove swamps. Of these the first and the last have produced the highest-yielding estates; the first because, owing to the light sandy nature and good natural drainage, deep and extensive rooting has been possible; the last only when artificially well drained, and when sufficient organic matter is present to render the soil light and porous. Analyses of typical soils are given, from which it appears that, with the exception of the peaty soils, the soils in Malaya are markedly deficient in phosphate, and it is stated that in all cases where differences of fertility not ascribable to texture or drainage have been noticed, they have been directly referable to the phosphate content.

An interesting paper discussing generally the merits of various systems of tapping was presented by Spring to the Batavia Rubber Congress (*India Rubber Journ.*, 1914, **48**, 631).

Details of large-scale experiments are given by Bosanquet (*ibid.*, p. 797), showing that higher yields of rubber are obtained by tapping on alternate days than by tapping each day. The former results in a decrease in the cost of production due to the lessening of the number of coolies required; fewer tools are needed, and the removal of bark is less.

A tree in the Waterfall garden, Penang, twenty-eight years old, has been tapped yearly since 1896, and has given during the years 1896 to 1913 (inclusive) a total yield of 98 lb. of rubber, the average for the last three years being

just over 13 lb. (*Gardens Bulletin, Straits Settlements*, 1914, **1**, 212).

Morgan records the results of some interesting experiments carried out to ascertain the influence of the skill of the tapping coolies on the yield of rubber obtained (*India Rubber Journ.*, 1915, **49**, 33). He found that the amount of rubber brought in by two coolies working under identical conditions might differ by over 30 per cent.; with gangs of coolies it was found that after arranging them in order of merit the order was kept with slight variations in later experiments. He considers that the value of many previous experiments on tapping systems is discounted by the fact that often allowances have not been made for the individual skill of tappers.

In the Federated Malay States "pink disease," due to *Corticium salmonicolor* (*C. javanicum*), developed to a considerable extent during 1913–1914 (*Agric. Bulletin, F.M.S.*, 1914, **2**, 238). This fungoid pest manifests itself generally as a pink incrustation on the branches or main stems, and develops most rapidly during rainy weather. It is known in many other countries, and is now a notifiable pest in the Federated Malay States (*F.M.S. Govt. Gaz.*, 1913, **5**, 1996). Other plants of economic importance, such as tea, coffee, and cinchona, are also attacked. The spores germinate on healthy bark, especially where moisture is present, *e.g.* in forks of branches; the growth is at first superficial, but the mycelium gradually penetrates the bark, causing exudation of latex, which is often the only sign of attack visible from the ground; it causes the bark to rot and sometimes attacks the wood, especially on smaller branches. Spraying with fungicides is impracticable owing to the height of the trees and the moist climate. All diseased portions should be cut out and burned, and tar applied to the cuts; if the main trunk becomes attacked, the trees should be destroyed by burning, but if this treatment is considered too drastic, tar should be applied to the tree for at least 2 ft. on each side of the diseased area; if this proves ineffective after about a month's further treatment, destruction of the tree is necessary. When burning of diseased material is difficult, owing to rain, the material should be drenched with 10 per cent. copper sulphate solution and buried at a distance from the plantations. A harmless fungus, *Oospora silva*, May, is sometimes mistaken for "pink disease." As "pink disease" develops rapidly and seems likely to be of considerable danger to the planting industry, it must be controlled by careful examination of all trees at least every three or four weeks. As many other plants are liable to attack, equal care must be taken with these to prevent danger of the disease spreading.

A small beetle (*Xyleborus parvulus*), allied to the shot-hole borer (*X. fornicatus*) of Ceylon has been found to

attack rubber trees in Malaya (*Bulletin* No. 20., *F.M.S. Dept. Agric.*, 1914, p. 13). It bores into the trunk or branches and usually attacks diseased trees, *e.g.* those suffering from fungoid pests. The borer does not often pass through the latex-bearing layer. Diseased trees attacked by *Xyleborus* should be destroyed by burning; tar or lead arsenite should be tried on healthy trees attacked by this boring beetle.

In Uganda, *Xyleborus camerunus*, Haged, *X. confusus*, Eichh., and *X. affinis*, Eichh., have been found to bore rubber trees (*Ann. Rept., Bot., For., and Sci. Dept.*, 1914, p. 4). The last-named species has been recorded on Hevea in tropical America, but has been unknown hitherto in Africa. It is thought that these pests may cause considerable damage if they become prevalent.

According to Baxter lime-sulphur wash acts as an efficient preventive of "canker" (*Trop. Agriculturist*, 1914, **43**, 342), caused by *Phytophthora faberi*. The experiments were carried out in Sarawak during the rainy season. Three sprayings were made (October, December, February) to a height of 3 ft. up the trunk. It was found that one man could spray 3 to 4 acres a day according to the nature of the plantation, and the cost amounted to about 10*d.* per acre for each spraying. The Ceylon Government mycologist in a criticism suggests that it is not certain that the disease in Sarawak is really "canker," as many symptoms of disease are attributed to "canker."

"Die-back" disease, caused by a species of *Diplodia*, possibly identical with *D. cacoicola* (*D. rapax*), attacks and kills young trees at Coquilhatville, especially when just removed from the nursery and placed in plantations (*Bulletin Agric. Congo Belge*, 1914, **5**, 312). Older trees are also attacked, but damage is usually confined to lateral branches, and the trees do not die. Young plants in the nursery should be sprayed with Bordeaux mixture, and those attacked by "die-back" should not be used for planting out, but should be burned. The diseased parts of young trees which are attacked after planting out, or of adult trees, should be cut out and burned; dead or dying trees should be destroyed immediately without allowing them to dry completely.

In 1913 a prize competition was arranged by the *India Rubber Journal* for the best essay on "an ideal rubber estate factory" intended to deal with 500,000 lb. of dry rubber a year. The prize essay by L. Smith, with illustrations and plans, and another submitted by A. Douglas, which are published in the *India Rubber Journ.* (1914, **48**, 795, 842), will be found to be of considerable value to those interested in the preparation of plantation rubber, and should be studied by all who are contemplating the erection of factories.

Owing to the war and the possibility of a shortage in

the supply of acetic acid required for coagulation, the possibility of local production of acetic acid was considered in Ceylon (*Ceylon Observer*, 1914, **54**, 2056). Vinegar from palm toddy (fermented juice of the toddy palm) and fermented coconut milk were found to be efficient coagulants. Dry distillation of coconut shells yielded crude pyroligneous acid which also gave satisfactory results.

Manihot.—The culture of *Manihot* at Mayumbe in the Belgian Congo was commenced about ten years ago (*Bulletin Agric. Congo Belge*, 1914, **5**, 297). Tapping was tried at first on the half-herring-bone system, but was abandoned as unsatisfactory, and the Lewa system is now employed. The juice of *Cissus adenocaulis* ("Mengwere") a plant abundant in Mayumbe, is a satisfactory coagulant.

Balata.—Some interesting experiments on different methods of tapping balata (*Mimusops globosa*) have been carried out at Onderneeming in British Guiana by Bancroft and Bayley (*Journ. Board of Agric., Brit. Guiana*, 1914, **8**, 20).

The methods employed were: (1) Local method of cross cuts about 10 in. apart up one half of the main trunk; (2) Venezuelan method, in which the tree is felled and tapped by incisions round the trunk; (3) V system; (4) herring-bone system. Systems (3) and (4) were found to be unsuitable for balata.

The experiments were carried out on a rather small number of trees, but they clearly indicated that the method prescribed in Guiana of tapping standing trees is satisfactory, as good yields are obtained, and the trees can be tapped again; while the Venezuelan method of tapping felled trees is more laborious, and, of course, destroys the tree.

The cutlass was found to be the best tool for tapping, as gouges and similar tools tear the fibrous bark. It was found that balata trees do not show wound-response like *Hevea* and "Jelutong" (*Dyera costulata*). The average yields of balata per tree obtained varied from about 2 to 3 lb., the greatest yield being 4 lb., compared with 5 lb. which was stated formerly to be usual (*Rubber and Balata in British Guiana*, p. 37).

If bleeding is conducted with ordinary care the wood is not likely to be exposed to insect attack.

Similar experiments have also been made by Anderson in another part of British Guiana (*Journ. Board of Agric., Brit. Guiana*, 1914, **8**, 34). These indicated that the local method of tapping prescribed by the Crown Lands' Regulations gives a greater yield of balata than the Venezuelan method, and does not destroy the trees. Six trees tapped by the local method yielded at the rate of nearly 5·6 lb. of balata per tree; six slightly smaller trees, felled and tapped by the Venezuelan method, yielded at the rate of only 3·6 lb.

per tree. The trees were larger than in the first mentioned experiments, and might be expected therefore to give higher yields.

The exploitation of balata in Ciudad Bolivar, Venezuela, is hardly remunerative owing to low market prices and the distances over which the balata must be transported, due to the destruction of trees in accessible areas (*Trade and Commerce of Ciudad Bolivar for* 1913, *Dipl. and Cons. Rept. Ann. Ser.*, No. 5360 [Cd. 7048—177], p. 3). Collectors are now turning their attention to chicle gum (see p. 165). In 1913, 2,162 tons of balata, valued at £414,688, were exported.

Fibres

Sisal Hemp and Henequen.—A report by the Director of Agriculture, Jamaica, on the prospects for the cultivation of Sisal hemp (*Agave sisalana*) and henequen (*A. fourcroydes*) in the island has been published in the *Journ. Jamaica Agric. Soc.* (1914, **18**, 334). Sisal hemp plants were obtained from the Caicos Islands in 1886 and planted at Hope on an area of 30 acres. This attempt, however, resulted in failure, as the plants poled when they were about two years old and died before the leaves were ready to be cut. In 1891 a supply of plants was procured from Florida and distributed to planters. Most of these plants were cultivated in Vere, but owing to a fall in the market price of the fibre the enterprise was abandoned. Recent efforts in Vere have met with greater success, and it has been proved that the Sisal plant will grow for several years without poling if planted in soil of a limestone formation, and that if cutting is commenced when the plants are three years old, instead of four years, the tendency to premature poling is reduced. It is considered that Sisal planting is well worth the attention of planters possessing soils of calcareous formation in the dry lowlands of Jamaica.

The henequen plant was introduced into Jamaica from Yucatan about sixty years ago, and plants of this species have been found growing freely in several districts. From observation of plants growing in the Botanical Gardens it is concluded that henequen can be grown on dry alluvial soils for many years without poling. There are large areas of dry soil in the Liguanea and St. Catherine plains which are quite unsuitable for other crops, but would probably be well adapted for *Agave fourcroydes*, and should yield profitable crops of fibre. Plantations of henequen have been established in St. Elizabeth and give promise of success.

The view is expressed that a large and remunerative fibre industry could be established in Jamaica by the cultivation of henequen on alluvial soils, and of true Sisal on the limestone formations in the dry and hot districts.

Cotton

India.—In the *Asiatic Review* (1914, **5**, 298) an account is given by T. Summers, C.I.E., D.Sc., M.I.C.E., of the potentialities of Sind as a field for the extension of cotton growing. About 100,000 acres are now planted along the Jamrao Canal, and even more could be grown if the canal had a greater discharge. The industry has not increased to any extent in other parts of the Province, chiefly on account of the fact that irrigation is almost entirely effected by low-level inundation canals which depend on the rise of the Indus in its flood season, and consequently have a very uncertain supply of water. Many of these canals only get water for two or three months in low inundations, but, for the successful cultivation of Sindhi and American cottons, a supply of water is required for four or five months.

Attention is directed particularly to an area of 5,000 square miles (3¼ million acres), most of which lies between Rohri and Hyderabad. Owing to the lack of water, the only crops at present grown in this region are 100,000 acres of cotton and 550,000 acres of other dry crops. It is estimated that soon after the proposed Rohri Canal is opened, the area under cultivation will be doubled; in four years a million acres will be opened up for cotton, and in ten years the whole three million acres will be available. The paper gives a full account of the Rohri Canal project, and discusses the conditions under which the canal and barrage would be remunerative. The opinion is expressed that the canal should be made first and the construction of the barrage postponed until it has been proved to be necessary.

In a report on cotton cultivation by the Director of Agriculture, Madras (*Government of Madras, Revenue Dept., G.O.* No. 2166, July 29, 1914), it is stated that the work of improving the cotton seed supplied to growers in Tinnevelly has been carried out both by selection of seed from the bulk, and also by developing and establishing single strains. Most of the improvements effected hitherto have been attained by the former method, but single strains have now been secured which give a large ginning yield, mature more uniformly, or give longer or stronger lint than the ordinary Tinnevelly cotton, and have become sufficiently well established to justify their cultivation on a commercial scale. Cotton grown on the Koilpatti Farm from seed selected from bulk gave a ginning yield of 24·6 per cent., and was reported by spinners to be intermediate between ordinary Tinnevellies and Cambodia in strength, but superior to both of them in other respects. Another crop of cotton grown on a seed-farm from seed raised from a single plant selection gave a ginning yield of

27 per cent. This product was compared by the spinners with the cotton mentioned above, and was found to be much superior in evenness of staple, slightly stronger, and equal in colour. The ryots sowed 200 acres with seed of this new variety, known as "Company No. 1," and the seed-cotton produced was to be collected by the Agricultural Department, ginned separately, and the seed returned to the growers. It was anticipated that by this means sufficient seed of the new variety would be obtained to plant 7,000 acres in the cold weather of 1914.

West Indies.—An account of the progress of the cotton industry in Antigua and Barbuda is given in the *Rep. Botanic Sta. and Exp. Plots, Antigua*, 1913–14. The area planted in Antigua amounted to 1,132 acres, or 332 acres more than in the previous year. The total crop of lint produced was about 128,750 lb., or an average of 111 lb. per acre. This yield was about 86 lb. per acre less than that of the year 1912–13, the decrease being mainly due to the shedding of the bolls. Considerable attention has been given to this question of boll-dropping, and it has been found that the chief factors responsible for it are unsuitable soil conditions, indifferent cultivation, and the prevalence of boll diseases. The following recommendations are made with a view to reducing losses from this cause. Heavy lands should be drained thoroughly. In order to avoid boll disease, the plants should not be too crowded, and all diseased bolls which fall to the ground should be collected and burned. The manurial requirements of the crop should be studied, and suitable manures applied when necessary. The crop should be planted early, in order that it may escape the ravages of the flower-bud maggot.

In Barbuda, 150 acres were planted in 1913–14, and a crop of 30,840 lb. of lint was obtained, or an average of 206 lb. per acre. The cotton caterpillar and flower-bud maggot made an appearance, but caused very little damage; and, on the whole, the cotton season in this island was fairly successful.

In Montserrat the weather during the cotton season of 1913–14 was somewhat unfavourable, the growth of the plants being retarded by a deficient rainfall in June and July, especially on the more sandy soils. In the *Rep. Botanic and Exp. Sta., Montserrat*, 1913–14, it is stated that 2,200 acres were planted and yielded 293,627 lb. of lint, or an average of 133 lb. per acre. An internal boll disease was prevalent in all parts of the island, and caused considerable damage. In some areas an abnormal condition of the plants, known locally as "chibble leaf," has been observed. This is not noticeable until at least 2½ months from the date of planting; its chief characteristics are a lankiness in growth of the leaves, which are fluted at the

margins, and present a pale green, glazed appearance. Bolls are but rarely developed on plants affected in this way. Selection experiments have been continued in Montserrat. The best type produced hitherto is that known as "Heaton 9," which yields a cotton realising 1*s.* 6*d.* or more per lb. The area devoted to this type in the present season (1914–15) exceeds 1,000 acres.

Drugs

Cascara Sagrada.—The *Amer. Journ. Pharm.* (1914, **86**, 387) contains an account of the history, growth, methods of collection, and bibliography of this drug (*Rhamnus Purshiana*). The tree is stated to occur in the states of Washington, Oregon, and Northern California, and in the Cascade mountains of British Columbia. It is said to prefer a light sandy soil with a good rainfall, and grows at altitudes varying from sea-level to 2,000 ft. The tree grows fairly rapidly, reaching a height of 20 to 30 ft. and a diameter of 6 to 8 in. in about ten years. Trees of over 4 in. are felled, the bark stripped during the summer months and cured by a few days' exposure to sunlight. During the period 1902–1912 the annual average production is stated to have been about 600 tons.

Ipecacuanha.—According to *Bulletin* No. 20, 1914, *Dept. Agric. F.M.S.*, p. 30, this crop has proved highly profitable in Malaya, but the demand is said to be small, and overproduction would result if attempts were made to cultivate it on a large scale. Plants at Kuala Lumpur have done well, but it is stated that they will need great care and attention in order to obtain successful results.

FORESTRY AND FOREST PRODUCTS

Forests of South Africa.—A useful summary of the present extent and resources of the forests of the Union of South Africa is included in a memorandum presented to the Dominions Royal Commission by the Chief Conservator of Forests of the Union ([Cd. 7706], 1914, p. 286). In comparison with the size of the country the indigenous forests in South Africa are very small; out of a total area of 473,954 square miles only approximately 450,000 acres are covered with indigenous forests. These are situated mainly along the mountain ranges within 200 miles of the southern and south-eastern coasts. In addition about 61,000 acres are planted with exotic trees, chiefly pines and firs. The output of the forests is not nearly sufficient to meet the needs of the country, the imports of timber during 1912 amounting to 10,189,756 cubic ft.,

valued at £618,253, of which more than half was pine. The present output of timber from the state forests is roughly 1,000,000 cubic ft. per annum.

The chief indigenous timbers are stinkwood (*Ocotea ballata*), the most valuable South African wood, much in demand for wagon building, and highly esteemed for furniture making and panelling; yellow-wood (*Podocarpus* spp.), largely used in the manufacture of sleepers, for wagon building, flooring, etc.; sneezewood (*Ptaeroxylon utile*), a very durable wood which meets to a large extent the demand for fencing poles; and white pear (*Apodytes didimiata*), assegai (*Curtisia faginea*), ironwood (*Olea laurifolia*), and flat crown (*Albizzia fastigiata*), all of which are employed in wagon and carriage building.

Forests of Uganda.—An account of a survey of Tero or South Buddu Forests, undertaken with a view to ascertaining the stocking of *Podocarpus milanjianus*, and also to determine the general contents of the forests, especially with regard to the number and species of trees suitable for converting into constructional timber, is given in the *Ann. Rep., Bot., For., and Sci. Dept., Uganda*, 1913–14, p. 7. The area of the Tero Forests, which border Lake Victoria, excluding that portion situated between Kasene and Masaka, is computed to be over 37,000 acres. It was found that *P. milanjianus*, which yields a valuable "yellow-wood" suitable for constructional purposes, is confined to Namalala and Tero proper, the northern sections of the forests; in the southern sections of Kaiso or Mesena and Malabigambo, it is replaced by *P. glacilior.* The latter is stated to be a much finer and larger tree, and the hope is expressed that the Department will be in a position in the near future to place large quantities of this timber on the local markets; the timber is said to be unquestionably the best which can be used locally for constructional purposes. Other species occurring in the Tero Forests which are known to yield good timber for these purposes are *Maesopsis berchemoides*, *Mimusops ugandensis*, *Mimusops* sp., and *Parinarium* sp., whilst the wood of several others is under trial.

The forest is being worked by the Department, which possesses an up-to-date saw-mill plant. During 1913–14 over 200,000 lineal feet of timber, valued at £1,588, were cut. Of this quantity over 120,000 ft. was *Podocarpus milanjianus* timber, and over 70,000 ft. *Maesopsis berchemoides.* The section of the forest being worked is now exhausted, but plans have been submitted for working larger and better-stocked sections, and it is thought that by carrying out the work in a proper manner, a permanent supply of timber, more than sufficient to cope with the demand in the Protectorate, will be ensured.

Gums and Resins

Chicle.—According to the Report on the trade and commerce of Ciudad Bolivar, Venezuela, for 1913 (*Dipl. and Cons. Rep., Ann. Ser.*, No. 5360 [Cd. 7048—177], p. 3), balata collectors in Ciudad Bolivar are now turning their attention more and more to chicle, which is used extensively in the United States as a basis for chewing gum (see also p. 160). Owing to political disturbances in Mexico, formerly the principal source of chicle, the production in that country has fallen off, and manufacturers are said to be enquiring for fresh sources of supply. Chicle is stated to offer considerable advantages over balata in Bolivar from the point of view of the collector, as it has not yet been collected to any great extent, and the trees are to be found much nearer the centres of distribution. Exports of chicle from Ciudad Bolivar in 1913 amounted to 68 tons, valued at £5,542.

Lac.—In India two crops of lac are taken in a year, one called "Kartiki" at the beginning of October (from inoculation done in June–July), and the other called "Baisaki" in June–July (from inoculation done in October). It has been found that the corresponding seasons in Ceylon, known respectively as "yala" and "maha," are more uniform owing probably to more or less variation of the air temperature and more regular rainfall, and as a result the lac takes nearly the same time to come to maturity each season, viz. about six months (*Trop. Agric.*, 1914, **43**, 152). Results are given of several trials which have been carried out in the Kandy and Hambantota districts, at two centres in each district. These centres are stated to have been selected with the double object of ascertaining the influence on lac production, and of introducing the industry into places in the vicinity of which lacquer work is carried on, with a view to supplying the local demand, and giving a fillip to the industry. The chief trouble so far experienced is the destructive nature of the red and other varieties of ants, but on the whole, the results are stated to have been satisfactory.

A general account is given in the *Bull. Econ. d'Indo-Chine*, 1914, No. 108, p. 227, of the methods employed in Tonkin for the preparation of the different forms of lac.

ECONOMIC MINERALS

Asbestos.—In *Bulletin* No. 18, 1914, *Geol. Surv.* of Tasmania, L. Hills gives the results of a geological reconnaissance of the country between Cape Sorell and Point Hibbs on the west coast of Tasmania. Asbestos occurs in this area in a belt of serpentine rocks which outcrop on the southern shore of Macquarie Harbour, at a locality

known as Asbestos Point, and a company has been formed to investigate the extent of the asbestos-bearing zone.

Trenches cut across the deposit show ramifying veins of chrysotile asbestos varying in width from an inch down to a mere paper-like film. The asbestos fibre is of good quality, and is stated to compare favourably with Canadian asbestos.

Gold.—*Memoir* No. 20—E. of the *Geol. Surv.* of Canada is an elaborate report on the gold fields of Nova Scotia, compiled by W. Malcolm from the results of investigations carried out by E. R. Faribault.

The gold fields of Nova Scotia occupy that half of the Province lying along the Atlantic coast and extending the full length of the peninsula. The rocks consist of an immense thickness of quartzites and slates folded in long east and west anticlines with intrusions of granite. In the vicinity of the granite intrusions, gneisses, schists, and phyllites are produced by the action of the granite upon the sediments.

The gold occurs chiefly in quartz veins, some of which cross the strike of the formation, but most of which are interstratified with the rocks and lie in the slate beds found in the quartzite formation. The veins are found on the domes, and the outcrops form a series of concentric ellipses or portions of ellipses. Sinking has revealed the presence of a series of saddle veins which do not come to the surface. The veins resemble the saddle reefs of Bendigo, Australia, which have been mined to a great depth.

The gold occurs in shoots, which pitch at a low angle to the east or west. Most of the gold is free milling, but sulphides commonly found in the veins carry a considerable quantity of gold that is not amenable to amalgamation.

The richest portions of the veins appear to lie in those parts of the domes where the strata have been fractured. These fractures are supposed to have been formed during the process of folding, and to have provided channels for the passage of the ore-bearing solutions.

In *Publication* No. 222, 1914, *Mines Branch*, *Dept. of Mines*, *Canada*, T. A. MacLean deals with lode mining in Yukon, and gives the results of an investigation of quartz deposits in the Klondike Division.

There has been a considerable amount of prospecting done on quartz-vein occurrences in the Klondike district, but development has been carried on in a desultory fashion, and little real mining has been done. Quartz veins occur abundantly. A number of deposits have proved sufficiently good to make further development desirable; the chief of these are situated in southern Yukon, and consist of quartz carrying argentiferous galena and gold. At certain mines on Windy Arm, the ore shows values in gold and silver which range from \$2 or \$3 up to \$96 per ton.

Iron Ore.—In *Publication* No. 254, 1914, *Mines Branch, Dept. of Mines, Canada*, E. Lindeman describes deposits of magnetic iron ore near Calabogie, in Renfrew County, Ontario. The magnetite deposits of this district occur in bands and lenses associated with amphibolites; and they generally occur along or near the contacts of these rocks with crystalline limestone. The quality of the ore is very variable; in some places it consists of fairly pure magnetite, in others it contains considerable amounts of hornblende, mica, and chlorite. The best quality of ore contains on the average about 61 per cent. of iron; but there is much material that does not average more than 47 per cent. The sulphur percentage varies from 0·012 to 1·65, and the phosphorus percentage from 0·17 to 0·578, indicating that the ore is not of Bessemer grade. Magnetometric surveys and actual mining work have shown that the deposits are of a very irregular character. The larger deposits vary in width from 1 to 7 ft., with a maximum length of about 150 ft. It appears, therefore, that this district is not likely to become an important producer of iron ore.

In *Publication* No. 303, 1914, *Mines Branch, Dept. of Mines, Canada*, E. Lindeman deals with the Moose mountain iron ore district, Hutton Township, Ontario. In this district there are large deposits of low-grade magnetic iron ore, occurring in pre-Cambrian schists.

The ore consists chiefly of a fine-grained siliceous magnetite, interbanded with cherty and quartzitic material. Its iron percentage varies up to about 45; and the average percentage of iron is between 30 and 40. An average sample gave 36·7 per cent. of iron, and 45·2 per cent. of silica. Fine grinding is necessary for effective concentration.

Tests have shown that by crushing the ore to 80 or 100 mesh, and passing it through a Gröndal magnetic separator, a concentrate can be obtained containing 65·6 per cent. of iron, 8·7 per cent. of silica, 0·029 per cent. of sulphur, and 0·019 per cent. of phosphorus. This concentrate, however, would require to be briquetted; and in spite of the fact that the ore can be very cheaply mined, it remains to be seen whether it can be worked successfully. It will be necessary to crush 2·2 tons of ore in order to obtain one ton of concentrate containing 65 per cent. of iron. When to this is added the cost of mining, and briquetting by the Gröndal process, it is clear that the most economical handling of the material will be necessary if these low-grade ores are to be worked at a profit.

Tin Ore.—In a paper read before the Federated Malay States Chamber of Mines, the Government Geologist has given an account of the deposits of tin ore in the limestone

of the Kinta Valley, Perak (Ipoh: The Times of Malaya Press, Ltd., 1914). In this paper he has collected the information available as to the localities of occurrence, modes of occurrence, and mineral composition of these interesting tin deposits in limestone, and has dealt with the origin of the deposits. It appears that a greater activity is being displayed in the working of these deposits, partly because many of the more readily worked alluvial deposits have been exhausted, and partly owing to the fact that the Chinese, who formerly did not understand how to open up these limestone occurrences, have now learned from the white miners how to proceed in developing them.

The Government geologist deals with two disadvantages that attend the working of pipes in limestone. One of these is that the lateral extension of the ore bodies is so limited that driving levels and stoping are out of the question, and the work of development is almost entirely confined to shaft sinking. The other is that tinstone is constantly accompanied by metallic sulphides.

Against these disadvantages, however, he points out that no pipe has been bottomed yet, and there is a reasonable expectation that the pipes extend as bodies of tin ore into the granite at unknown depths below the present workings. As regards sulphides, the roasting necessary to get rid of the sulphides is a simple operation. Moreover, the Government geologist thinks there is reason to hope that the sulphides will diminish in amount as the pipes approach the granite, though no diminution has been observed in existing workings.

Uranium Ore.—In *Bulletin* 580—H, 1914, *U. S. Geol. Surv.*, E. T. Wherry describes an occurrence of carnotite at the eastern termination of Mount Pisgah, about three-quarters of a mile north of the town of Mauch Chunk, Pennsylvania. The carnotite occurs in a coarse-grained conglomerate lying near the base of the Pottsville formation (Pennsylvanian). The cement of the conglomerate is in most places silica, the rock being a very hard quartzite, but here and there calcite takes the place of quartz. The greater part of the carnotite occurs as a replacement of the calcareous cement of certain portions of the conglomerate. The carnotite appears to have been deposited from the circulating surface waters. It probably does not extend below the ground-water level, and may be restricted to a very shallow zone.

A re-calculated analysis shows that the water-free carnotite contains 21·73 per cent. of vanadic oxide (V_2O_5), 68·99 per cent. of uranium oxide (UO_3), 7·86 per cent. of potash (K_2O), and 1·42 per cent. of lime (CaO). There is as yet insufficient data to warrant any statement as to whether the deposit can be worked at a profit. It is considered

doubtful whether much of the material contains over 1 per cent. of uranium oxide. It is pointed out, however, that the cost of shipping the ore to consumers would be far less than that for the Colorado deposits, and a profit of $25 per ton could be expected even on 1 per cent. ore. Conservative prospecting is recommended.

In *Prospector's Handbook* No. 1, the Geological Survey of Canada has published a brief account of uranium ores under the title "Notes on Radium-Bearing Minerals," by W. Malcolm (Dept. of Mines, Ottawa, 1914).

General.—In *Bulletin* No. 34, 1914, *Geol. Surv. of Victoria, Australia*, the Director of the Survey gives an account of the economic geology and mineral resources of Victoria, in which he deals with the physiography of the country, the stratigraphical succession, gold mining, coal mining, and the mining of various other economic minerals.

The area of Victoria is about 87,884 square miles, of which the Palæozoic and older rocks occupy about 26,900, whilst the Mesozoic occupy about 1,900, and the Cainozoic about 59,000 square miles. About 8,000 square miles of the country has been surveyed in moderate to close detail, and a large proportion of the remainder has been examined sufficiently well to permit of fairly accurate representation on the published geological maps of the State.

It was not until 1851 that the State began its history as a gold producer. In that year a reward of £200 was offered for the discovery of a goldfield within 200 miles of Melbourne. Discoveries followed in quick succession. In 1852, 40,000 men were camped at Ballarat, 25,000 at Mount Alexander, and 40,000 at Bendigo, and the gold output for that year was 2,286,535 oz. The gold output from alluvial and quartz mining from 1851 to 1913 was 73,483,148 oz., valued at £293,550,927.

Bituminous coal of Jurassic age occurs at various places in the southern portion of the State. Out of a total output of 589,143 tons, valued at £258,455, during 1912, the State coal mine at Wonthaggi contributed 455,658 tons, valued at £184,056. Sufficient boring has been done around this mine to show that there is about 20,000,000 tons of payable coal yet to be extracted, so that, at the present rate of output, the coal supply is secure for many years.

Of greater extent than the bituminous coal deposits are the deposits of Tertiary brown coal, which are probably the thickest in the world. At Morwell 780 ft. of coal was passed through in a bore 1,010 ft. deep. It is estimated that Victoria probably contains not less than 30,000,000,000 tons of brown coal.

Among other economic minerals, it may be mentioned that Victoria has large deposits of high-grade diatomite (see this BULLETIN, 1913, **11**, 174).

At Wangarabell, in East Gippsland, molybdenite occurs in a lode traversing granite in sufficient quantity to be probably of economic value. Other economic minerals worked in the State include gypsum, magnesite, and ores of antimony, copper, iron, lead, manganese, silver, tin, and tungsten.

NOTICES OF RECENT LITERATURE

Lodges in the Wilderness. By W. C. Scully. Pp. xiv + 252, Crown 8vo. (London: Herbert Jenkins, Ltd., 1915.) Price 5*s.* net; post free, United Kingdom 5*s.* 4*d.*, abroad 5*s.* 6*d.*

Mr. Scully held in the nineties the now lapsed office of Special Magistrate for the Northern Border of Cape Colony, and the various journeys in the Great Bushmanland Desert which he describes in this book were made in the course of his duties.

The tract of 50,000 square miles, there or thereabouts, known as the Bushmanland Desert, lies in the north-western corner of the present Cape Province, and is bounded on the north by the Orange River, on the west by the Atlantic Ocean. The greater portion of it is a complete solitude. "Here and there" (writes Mr. Scully) "ephemeral mat-house villages, whose dwellers are dependent on the spare and uncertain bounty of the sky, will, perhaps, be found for a season. But when the greedy sun has reclaimed the last drop of moisture from shallow 'pan' or sand-choked rock-saucer, the mat-houses are folded up, and, like the Arabs, these dwellers steal silently away from the blighting visage of the Thirst King."

The above passage gives the key at once to the contents of the book and to the author's method of approaching his subject. To Mr. Scully the desert is something essentially personal—he feels in it the direct manifestation of a living evil and cruel force. And he has known it in every hour of the twenty-four, he has met with intolerable hardships in his journeyings through it. It has scorched him with heat of 129° Fahrenheit by day, so that he has shivered in the sudden drop to a mere 80° at night. Worst of all, it has inflicted on him the agony of parching thirst.

But even at this worst it has retained for him its fascination. It threatens, it punishes, it repels—and yet, in some mysterious way, it attracts. The same fascination is of course exerted on many natures by other deserts—there are frequently recorded instances of it by travellers in the Great Sahara, for instance, and in one case a popular living novelist has found in it his *leit-motiv*—but Mr. Scully has expressed this point of view more clearly than any

other writer we can recall. The sort of feeling which he has for the desert does not lend itself to partial quotations; to appreciate it you must read the book itself.

This brief outline of Mr. Scully's method will be sufficient to show how it stands at the exactly opposite pole to Mr. Macdonald's fine South African work *The Conquest of the Desert*, though physically and topographically the Kalahari Desert described by the latter and the Bushmanland Desert are but little removed from each other. Mr. Macdonald, a scientist, writing when agricultural science is at last beginning to come to its own, sees in the desert only the raw material for future fertility, and his severely practical imagination peoples the solitudes with sturdy British colonists. To Mr. Scully the desert is not and never will be anything but desert, the absolute negation of life and civilisation. But just as he found it, so he has written it down, and there is no denying the power of what he has written. *Quot homines, tot sententiae!*

MALTA AND GIBRALTAR ILLUSTRATED. Compiled and Edited by Allister Macmillan. Pp. vi + 515, Demy 4to. (London: W. H. & L. Collingridge, 1915.) Price £3 3*s*.

There is very little literature on either Malta or Gibraltar in English, and what there is, is out of date. For this reason alone the publication of the present volume is distinctly welcome, and, in this war time, opportune. Mr. Macmillan has moreover secured the collaboration of the leading people in both Malta and Gibraltar, and his book is therefore not only interesting—which it most certainly is—but authoritative.

For instance, Dr. John Borg, the Superintendent of Public Gardens and Plantations, writes on "Agriculture and Horticulture in Malta," which he points out is still being carried out on the lines of its original introducers—the Phœnicians. Nor does Dr. Borg consider that, conditions in Malta being what they are, these old methods can be improved upon. A strong feature of Malta agriculture is the kitchen-gardening. Maltese vegetables, Dr. Borg claims, are rarely equalled and never surpassed by the productions of other countries. "The catalogues of good seed merchants of Europe are often crowded with names of vegetables of Maltese origin, and this shows that the good qualities of Maltese vegetables are widely known and appreciated. . . . Maltese settlers have introduced kitchen-gardening on Maltese lines with much success in Algeria, Tunis, Egypt, the Ionian Isles, the Levant, and in several parts of North America, and most of them are careful to renew periodically their stock of seeds by fresh importations from Malta. Our vegetables have found their way also to the tropical regions of Africa and Asia, and lately to South America and Australia."

Equally thorough treatment is given by other local authorities to their respective subjects, *e.g.* Prof. Thomas Agius, Professor of Physics in the Government University and Officer-in-Charge of the Meteorological Observatory, writes on the "Climate of Malta"; Mr. Robert Galea, Lecturer on Engineering and Architecture in the University of Malta, on the "Geology of the Maltese Archipelago"; Dr. Augusto Bartolo, assistant editor of the *Daily Malta Chronicle*, on the "History of the Maltese Islands"; Mr. John Reynolds, late Deputy Director of Public Instruction, on "Education"; Prof. Vassallo, Professor of Constitutional and International Law at Malta University, on "The Constitution of Malta"; while ecclesiastical, military, commercial, and social matters in the island are all discussed at length.

The section on Gibraltar is no less complete; the "History of Gibraltar," by Major Pollard, Librarian of the Garrison Library, is specially noteworthy.

The book is well printed and illustrated throughout. It supplies a distinct want and supplies it well, but it would have been easier reading if printed two columns to the page.

CYPRUS: A SHORT ACCOUNT OF ITS HISTORY AND PRESENT STATE. By Colonel A. O. Green, (late) R.E. Pp. vi + 118, Demy 8vo. (Kilmacolm: M. Graham Coltart, 1914.) Price 2*s.* 6*d.* net; post free, United Kingdom 2*s.* 10*d.*, abroad 2*s.* 11*d.*

This is a bright, agreeably written account of the island, which by the fortunate cessation of the Turkish suzerainty is at last completely a British possession. The notes from which it was written were originally put together by the author, who frequently visited Cyprus on official duty from Egypt in 1896, but have now been brought down to date.

Colonel Green makes very clear the paralysing effect that Turkish rule, and in more recent times even Turkish suzerainty, have exercised on this naturally highly fertile and productive island, and enables us to see that the removal of the last item of Turkish authority is the best thing that could have happened for the Cypriots themselves. He looks forward to seeing Cyprus one of the most prosperous of our Crown Colonies. Besides its natural economic resources, the island possesses considerable claims to become a popular tourist resort. On the coast from October to May one finds the temperature of a fine English summer, while Mt. Troödos (the Olympus of the Ancient Greeks) can afford in July, August, and September, at an elevation of 6,000 ft., a variant of the summer atmosphere of the Engadine, and this only thirty hours from the heat of Cairo, and nineteen from Port Said.

The book is well illustrated with photographs. As a work of reference of course it does not compare with the latest edition of the *Handbook of Cyprus*, but it is distinctly readable as a popular account of the island and attractive.

Le Turkestan Russe. By A. Woeikof, Honorary Professor of Physical Geography at the University of St. Petersburg. Pp. xii + 362, Demy 8vo. (Paris: Librairie Armand Colin, 1914.) Price 8 francs; post free, United Kingdom 6*s*. 8*d*., abroad 6*s*. 10*d*.

Prof. Woeikof's knowledge of Russian Turkestan (in which he includes the vassal Khanates of Bokhara and Khiva) is practical as well as theoretical, for the author occupied the summer of 1912 in a tour of the country, passing along the whole length of the main line of the Transcaspian railway from its starting-point at Krasnovodsk to Tashkent, the capital of the colony, visiting Bokhara and Samarcand, and proceeding up the Ferghana branch to Andijan and along the new line from Khokand to Namangan.

Prof. Woeikof's considerable previous study of his subject, coupled with his careful observations on his tour, have enabled him to furnish a very complete account of this large colony. A comprehensive, scientific, modern work on this colony has hitherto been lacking; for even up till the beginning of the twentieth century Turkestan was, M. Woeikof says, "the Cinderella of the Russian Government." M. Woeikof describes the soil, the climate (one should rather say climates), the agriculture, and the population. And he has a nice gift of illuminating the scientific with the human touch.

For instance, after the Russian conquest of the Transcaspian province, the question of railway construction came up. General Tcherniaiev, the first conqueror of Turkestan, insisted that it was impossible to carry any line across the huge expanses of sand desert which are so frequent in certain parts of the country, and wrote a whole series of articles in the *Novoe Vremya* to prove it. General Annakoff, who was entrusted with the actual construction of the railway, took up the work in obedience to the Imperial command, but with little hope of success—and succeeded. Yet in 1896 to each train running over one particular 14-mile stretch of line was attached a special car, with workmen armed with spades. Every time that the train stopped through the constantly drifting sand blocking the line, this special gang had to turn out and clear the track. Over £4,000 a year was being paid out for this work on this one small section, but in the end man conquered. As a result of a long series of experiments, M. Paletzky, a forest expert, found exactly the type of shrubs which would stand the climate and act as a

"binder" on the sand. A couple of remarkable photo graphs—one showing the billowing sand dunes before planting, the other the same dunes flattened down and transformed into comparative stability by judicious planting—illustrate the point far more effectively than it can be described in print.

The general agriculture and stock-breeding of the colony receive due attention from Prof. Woeikof. To the question of cotton cultivation a special chapter is given, and there are many other references. M. Woeikof points out that cotton manufacture is already the most important Russian industry, 360,000 metric tons of cotton (equivalent to a value of some 28 million pounds sterling) being worked by the 730 Russian factories every year. Of this total half already comes from the Russian colonies, over two-fifths from Turkestan. It was as recently as 1880 that the Russian Government introduced American Upland cotton into Turkestan, previous experiments with Sea Island cotton having been unsuccessful. The success achieved by the Government plantation of American cotton brought the private firm on to the field, and the industry has gone rapidly ahead. Experiments now being made in crossing Upland with Egyptian cotton seem to be meeting with some success.

The cotton province par excellence is Ferghana, the bulk of which is valley and plain. Here "Cotton is King," nothing else is grown, and cereals have to be imported. Irrigation is good, the climate warm, and the people have developed a great skill in cotton-growing. The average return per acre cultivated is at present rather higher in Ferghana than in the other Turkestan provinces and in the United States, though a great deal less than that obtained in the Egyptian delta. But M. Woeikof points out that much more can be planted, and the yield per acre can certainly be increased, so that the total production is eventually likely to reach under improved methods of irrigation a very high figure. What is wanted is capital.

We have no space to refer to many of the other interesting sections of Prof. Woeikof's book, though he has much that is interesting to say of, *inter alia*, fruit-growing and vineyards. It is worth noting, by the way, that near Tashkend apples are grown on a large scale with summer temperatures considerably higher than in the world's recognised apple-growing districts.

M. Woeikof asks the question whether the acquisition of Turkestan, which he says was forced on her, has been of benefit to Russia, and answers it in the affirmative, inasmuch as this fertile colony can, under its abundant sunshine, supply all sorts of agricultural products that could not be raised in European Russia or in Siberia.

That Turkestan is a distinctly dry country is not in his

opinion any objection to its agricultural future. That is only a question of irrigation—for the engineer. From the melting snow off the great snowfields in the mountains, the engineer, he holds, would have no difficulty in drawing a constant water supply for the valleys and plains. M. Woeikof indeed looks forward to the day when every drop of this snow water can be utilised, and he declares triumphantly that "the dry countries with an artificial irrigation system—these are the countries of the future, and their irrigation surface should produce far richer and larger crops than a similar amount of surface in a damp country." This theory, it will be observed, takes no account of the cost of production, and clearly the irrigation works would have to be on a gigantic scale, but the Russian cotton factories are already subsidised by the Government, and it would be the Government of course who would have to go a step further back and subsidise, so to speak, the actual cotton-growing soil.

But if M. Woeikof sees visions, he sees them very clearly, and he is not looking, as we understand him, to the immediate future. Moreover, it is just this touch of imagination, this spirit of indomitable but always intelligent optimism, that makes this book so attractive. There is spirit in it, not only facts; enthusiasm, not only observation. Briefly, a book valuable not only for its abundant information, but also for the manner in which that information is arranged and illustrated. In view of the fast growing British interest in all things Russian, an English translation should find a ready market here.

Guide to Rhodesia: For the use of Tourists and Settlers. Pp. xvi + 395, Foolscap 8vo. (Bulawayo: Beira and Mashonaland and Rhodesia Railways, 1914.) Price 2*s.* net; post free, United Kingdom 2*s.* 3*d.*, abroad 2*s.* 4*d.*

A thoroughly practical and informative little volume, well got up, well and plentifully illustrated, and generally attractive. It includes articles by authorities in their respective Rhodesian departments, a well arranged and clearly written collection of general information, maps, a good bibliography of Rhodesia, and an index. It should be indispensable to the new-comer to the country, whether tourist, sportsman, or settler.

Rubber Recueil: A Series of Papers about Rubber, its Botany, Culture, Preparation and Commerce. Pp. x + 609, Demy 4to. (Amsterdam: J. H. De Bussy, 1914.) Price 17*s.* net.

This handsome volume contains the papers presented to the Rubber Congress which was held in connection with the International Rubber Exhibition at Batavia in September 1914. Leading authorities on the various sub-

jects connected with the cultivation and preparation of rubber and its commercial utilisation were asked to contribute papers by the organisers of the Congress, and these invitations met with a very gratifying response. The papers submitted cover a wide field, and as they deal with many points of importance which are now attracting the attention of rubber producers, they will be of much interest to all who are in any way connected with the rubber industry.

The papers are divided into six groups, viz. Botany and Phytopathology (pp. 1–141); Climate and Soil (pp. 143–182); Cultivation and Tapping (pp. 183–353); Preparation and Chemistry (pp. 355–465); Economic Questions (pp. 467–583); and Commerce (pp. 585–609). A detailed notice of the various papers cannot be attempted here, but the following general review of the different sections will serve to indicate some of the principal subjects dealt with.

The section devoted to Botany and Phytopathology contains, in addition to a number of general papers on rubber plants, important contributions on "Die Funktion des Milchsafts," by Prof. Dr. H. Kniep, of Würzburg; "Die Erneuerung von *Hevea*-Bast nach dem Anzapfen," by Dr. J. Kuyper, of Java; and "Zur Blütenbiologie von *Hevea* und *Manihot*," by Dr. P. Arens, of Java. The animal pests of rubber and gutta-percha plants are dealt with by Dr. K. W. Dammerman and Dr. W. Roepke, of Java, and the fungoid diseases of Hevea by Mr. T. Petch, of Ceylon, and Dr. A. A. L. Rutgers and Dr. P. Arens, of Java.

The second section, on Climate and Soil, includes a paper "On the Climate of the principal rubber-producing Countries," by Dr. W. van Bemmelen, of Java, and one on the climate of the rubber districts of the Congo, by M. J. Vincent. The question of rubber soils is dealt with by Dr. E. C. J. Mohr, of Java, and Dr. J. G. C. Vriens, of Sumatra.

The section devoted to Cultivation and Tapping is the largest in the book, and contains reviews of the cultivation of Para rubber in Java, by Dr. W. R. Tromp de Haas and Dr. C. J. J. van Hall; and in Malaya by Mr. L. Lewton-Brain, the Director of Agriculture in the Federated Malay States. Other papers deal with the cultivation of *Manihot Glaziovii*, *Funtumia elastica*, and Castilloa trees, and also with various problems connected with the planting, tapping, and manuring of Hevea trees. The question of tapping systems is dealt with by Mr. F. G. Spring, of the Federated Malay States, and by Dr. A. W. K. de Jong, of Java. Dr. Tromp de Haas also contributes a paper on "The Culture of Gutta Percha."

In the section on the Preparation and Chemistry of Rubber the most important paper is by Mr. J. G. Fol, of the Netherlands Government Rubber Experimental Station at

Delft, who deals with the important question of "The desirability of International Testing Methods for Raw Rubber." Prof. G. van Iterson, Jr., who is in charge of the Delft Experimental Station, also contributes some "Remarks on scientific Rubber Research and its importance for the prospects of Plantation Rubber." Of the other papers in this section, three deal with methods of coagulation (by Dr. P. Schidrowitz, Mr. P. S. Clignett, and Mr. R. W. Lash), whilst the question of tackiness is considered by Dr. K. Gorter.

In the section devoted to Economic Questions the papers deal with such subjects as the acquisition and transfer of land in Java, Sumatra, and Malaya; the financial aspects of rubber cultivation; the buildings and machinery suitable for rubber estates; and the sanitation of rubber plantations in Malaya. The concluding section of the volume is devoted to a study of "The World Trade in Raw Rubber," by Mr. E. de Kruyff, of Java.

The papers are printed in English, French, Dutch, or German, but out of the total of fifty-seven papers twenty-six are in English; in addition, English translations are given of six of the papers and summaries of eight more. The book is therefore quite suitable for English readers.

The Editing Committee of the Congress are to be congratulated on the results of their labours. The book is exceedingly well produced in every respect, the printing, paper, and illustrations being alike good.

COCOA. By Dr. C. J. J. van Hall. Pp. xvi + 575, Demy 8vo. (London: Macmillan & Co., Ltd., 1914.) Price 14*s.* net; post free, United Kingdom 14*s.* 5*d.*, abroad 15*s.*

Cocoa planters are well provided with handbooks to their craft, and it is fitting that the latest addition to the list should be so worthy of recommendation: Dr. van Hall's book has been eagerly awaited by tropical agriculturists, and its appearance fully justifies the expectations held regarding it.

The remarkable rise of the native-owned cocoa industry of the Gold Coast and the relatively careless management of many of the plantations in the Old World might lead to the conclusion that scientific method in cocoa cultivation is, in large measure, unnecessary. Such ideas are quickly dispelled by a study of the book under notice, and the author is to be congratulated on his admirable treatment of the subject, which so clearly points to the importance of a sound understanding of the principles upon which the profitable production of a high-class cocoa is based.

The plan of the book is one familiar to most planters and needs no special reference. Chapters IV. and V. form probably the best available account of the botany of the cocoa tree, while the section on "Cultivation" derives

much of its practical value from the attention paid to the physiology of the plant. In the hands of Dr. van Hall the question of "shade or no shade" seems to lose much of the mystery usually attaching to this problem, the author regarding the special conditions of cultivation obtaining in certain countries where no shade is adopted (*e.g.* Grenada) as affording an explanation of the function of the shade trees, and the ability of the countries in question to dispense with a practice so strongly upheld by planters elsewhere. The chapter on Fermentation and Drying provides a sound and most readable discussion of these important processes. In recent years there has been a tendency to exaggerate the significance of the fermentation, and somewhat original suggestions for the preparation of the bean, based upon a growing knowledge of the chemical changes taking place during this process, have from time to time been put forward. These suggestions receive no serious consideration from Dr. van Hall, and, while recognising the value of a thorough fementation carried out on well-ordered lines, the author considers it a mistake to suppose that cocoa of mediocre quality can be improved to any great extent by changes in the fermentation process: "the quality of cocoa is almost wholly dependent upon the variety grown and upon unknown characters of soil and climate." An important section of the book affords a detailed account of the methods of cultivation and preparation adopted in the great producing countries. A careful comparison of the methods described clearly indicates the necessity for recognising that cultural methods must depend, in great measure, upon local circumstances; it is useless to formulate a "best" method of cultivation, equally applicable to all regions. The book is well printed, and illustrated with many excellent photographs, some of which are of particular interest.

RUTHERFORD'S PLANTERS' NOTEBOOK. Sixth Edition, thoroughly revised and further enlarged. Pp. lxiv + 478, Demy 8vo. (Colombo and London: Times of Ceylon Co., Ltd., 1914.) Price £1; post free, United Kingdom £1 0s. 5*d.*, abroad £1 0s. 10*d.*

This practical handbook is too well known among planters and agricultural officials to call for detailed review. The present revised and enlarged issue has appeared in place of the reprint of the fifth edition originally contemplated and incorporates several useful new features. The book is prepared for the use of planters in the East, and in the cultural section the main crops dealt with are Tea, Rubber, Coconuts, and Cocoa. The chapter on rubber has been enlarged to include the results of the most recent experience, and gives a useful résumé of the recommendations of the Rubber Growers' Association in regard

to the treatment of latex and curing of rubber. Coconuts are now considered of sufficient importance to be dealt with in a separate chapter. The new preface refers also to a separate section on Cocoa, but the index and text show this product as dealt with in a chapter on General Products in which the more important features of the cultivation of Cocoa, Tobacco, Sugar-cane, Jute, Manila Hemp, Sisal, and Bowstring Hemps and Ramie are briefly described. For those unacquainted with this book it may be mentioned that it contains, in addition to the purely agricultural chapters, useful sections dealing with "Cost," Manuring, Insurance, Estate, Medicine, Law, and Book-keeping.

Reference must be made to the practical form in which the notebook is prepared. The exhaustive indexes, absence of unduly numerous advertisements, and the liberal provision of indexed blank pages for notes will be appreciated by practical men, while the binding should survive the treatment to which the volume will be subjected.

FOREST VALUATION. By H. H. Chapman. Pp. xvi + 310, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1915.) Price 8*s.* 6*d.* net; post free, United Kingdom 8*s.* 11*d.*, abroad 9*s.* 3*d.*

ELEMENTS OF FORESTRY. By F. F. Moon and N. C. Brown. Pp. xvii + 392, Demy 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1914.) Price 8*s.* 6*d.* net; post free, United Kingdom 8*s.* 11*d.*, abroad 9*s.* 3*d.*

STUDIES OF TREES. By J. J. Levison. Pp. x + 253, Crown 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1914.) Price 7*s.* net; post free, United Kingdom 7*s.* 4*d.*, abroad 7*s.* 6*d.*

The development of the American forest policy during the last twenty years has been remarkably rapid. The first forest reserves were set aside barely twenty years ago, yet the present gross area of the National Forests is 186,000,000 acres. Many institutions now give degrees in forestry, a large number of agricultural schools have forestry courses, whilst the study of trees is also attracting the attention of many outside educational establishments. As a result a demand has arisen for books on the subject written from an American standpoint, and the books now under notice are admirably adapted for these three categories of students.

Chapman's book is intended primarily as a text-book of Forest Finance, but deals principally with Forest Valuation, that is to say the determination of the value of standing timber, both mature and immature, of forest soil, and of the forest as a whole. Only a single chapter is devoted to

Forest Statics. The first four chapters give a summary of economic subjects and tenets with special reference to interest, whilst an entire chapter is devoted to an explanation of the derivation of the formulæ of compound interest. Subsequent sections deal with "Investments and Costs in Forest Production," "The Valuation of Forests," "The Appraisal of Damages," "Forest Taxation," "Stumpage Values," "Future Value of Forest Products," "Risks," "Field Appraisals of Timber Stumpage," and "Comparison of Forest Values with Agricultural Values." An effort has been made to indicate the relation of the methods of forest valuation to the customs and principles of business accounting, and so enable accountants and business men to harmonise the methods used in computing cost and value for forest property with the forms and ideas with which they are familiar. Particular emphasis is laid on stumpage values, sale values, damages, and other subjects which are considered of greater practical interest in the United States than the determination of expectation value of forest soil, which is such a conspicuous feature of European Forest Finance.

The volume by Moon and Brown is a general elementary text-book suitable for students taking a forestry course in an agricultural college. The first part deals with the principles of forestry, commencing with a brief outline of its development in Europe and the United States, followed by an account of the structure of trees and the bionomics of a forest. Other subjects discussed include silvicultural systems of management, improvement cuttings, artificial regeneration, forest protection, lumbering, the utilisation of forest products, including wood-pulp, tanning materials, wood distillation, and maple sugar, the technology of wood and its preservation, and forest economics and finance. The subjects are necessarily dealt with briefly, but this part of the volume serves as an excellent introduction to the more detailed text-books on the subject. The second part gives an account of the forests of the United States, which are divided up, for the purpose of description, into the following regions: Northern Forest, Southern Pines, Central Hardwoods, Prairie or Fringe Forest, Northern Rocky Mountain Forest, Southern Rocky Mountain Forest, and Pacific Coast Forest. A short bibliography is appended to each chapter and there are a number of useful appendices, including a glossary of forestry terms.

Studies in Trees is intended for beginners, and gives briefly the most important facts concerning the identification, structure, and uses of the more common trees of the United States, and considers their habits, enemies, and care. The fundamental principles of forestry are dealt with, and there is a separate chapter on the identification, properties, and uses of certain timbers. The book con-

cludes with a brief outline of a scheme of nature study as applied to trees.

AN INTRODUCTION TO THE GEOLOGY OF NEW SOUTH WALES. By C. A. Süssmilch. Pp. xviii + 269, Crown 8vo. (Sydney: Angus & Robertson, Ltd.; London: The Oxford University Press, 1914.) Price *7s. 6d.* net; post free, United Kingdom *7s. 10d.*, abroad *8s. 2d.*

This is a second edition. The first edition appeared in 1911, and it may be inferred that the selling out of the first edition in such a short time shows clearly that the book has supplied a widely felt need among readers in New South Wales.

An introductory chapter deals briefly with the sedimentary sequence, and Chapter II. gives an account of the physical geography. The succeeding chapters deal in order with the various systems of strata. In each there is a summary of the period dealt with, and economic aspects are briefly touched upon. A concluding chapter deals with igneous rocks, and there is a glossary of geological terms.

The book assumes a knowledge of the elements of geology, and for that reason one might, perhaps, fairly expect a fuller treatment of the economic aspects of geology, since most of the readers of the book are likely to be largely interested in mining. The mining geology of the country is worthy of more attention than the author has given to it in this book, though special headings are provided for economic features.

Among the misprints noticed in the book, the following may be mentioned: "Prostospongia" (p. 28); "Prœtus" (pp. 51 and 266); "Queesland" (p. 174); "Ornithorrhyncus" (p. 204); "Premo-Carboniferous" (p. 242); "riebickite" (p. 252); "spillite" (pp. 247 and 267).

The book is a clearly and simply written statement of New South Wales geology. It is well printed, excellently illustrated by maps, photographs, and sections, and can be highly recommended for use, in spite of the fact that it could be much improved by further elaboration and fuller treatment.

THE HYDROGENATION OF OILS. By Carleton Ellis. Pp. x + 340, Roy. 8vo. (London: Constable & Co., 1914.) Price 16*s.* net.; post free, United Kingdom 16*s.* 6*d.*, abroad 17*s.* 1*d.*

It is gratifying to note that this, the first book dealing exhaustively with a recent and most important branch of the oil and fat industry (see this BULLETIN, 1913, **11**, 660), is in English. German industry has benefited considerably in prestige and in technique from the numerous books on applied science published there, and it is to be hoped that the appearance of this book indicates that British and

American technologists are beginning to realise the advantages of putting their experience on record.

The first chapters of Mr. Ellis's book deal with the methods of hydrogenating oils and outline all the important processes employed. The action, manufacture, and uses of various metals as catalysts are next described, particular attention being paid to nickel catalysts, which, on account of their cheapness and efficiency, are used largely; in this connection the chapter on nickel carbonyl is particularly interesting. The chapter dealing with the analytical constants of hydrogenated oils will prove of special value to analytical chemists, although it must be confessed that the problem of detecting hydrogenated oils seems likely to prove very difficult, or even insoluble. The following chapters on edible hydrogenated oil and on the uses of hydrogenated oils (chiefly in soap making) are exhaustive and show the important place that hydrogenated oils are destined to take. About one-third of the book deals with the technical preparation of hydrogen, the cheap manufacture of which gas in a pure state is an essential factor in oil hydrogenation; this section of the book will prove of great value to technologists. The appendix gives a report of a recent important case of patent litigation in which a large amount of valuable evidence relating to oil hydrogenation was brought forward.

In the preface the author states that he has refrained purposely from commenting critically on the many processes in view of the comparatively recent introduction of oil hydrogenation; this course is no doubt wise, but it might be argued that the book has been rendered less readable by this omission, as it consists largely of a series of abstracts of patents and processes.

The book is clearly written, well printed and illustrated, and will form a valuable addition to the library of chemists, technologists, oil manufacturers, and others.

Imperial Defence and Trade. By Frederick A. Kirkpatrick. Pp. v + 107, Med. 8vo. (London: Royal Colonial Institute, 1914.) Price 2*s.*; post free, United Kingdom 2*s.* 3*d.*, abroad 2*s.* 4*d.*

This is the first of a series of special competitive monographs to be published by the Royal Colonial Institute, and it won, in open competition, the Institute's grant of 100 guineas and a gold medal. In each monograph the question of how to make closer the union between the Mother Country and the various parts of the British Empire is to be scientifically considered in different lights.

The theme set in this first case was "The Interaction, if any, between the economic interests of a state and its foreign relations, with special reference to the question whether, or how far, the self-governing states of the British

Empire (with or without a more centralised system of Government than it now has) could co-operate permanently for the purpose of defence without co-operating for the purpose also of trade." Mr. Kirkpatrick works out this theme carefully and quite dispassionately, and concludes that on every ground "commercial co-operation is an indispensable condition of defensive co-operation." A careful bibliography of books providing an introduction to the main topic is given.

THE GERMANS IN AFRICA. By Evans Lewin. Pp. 31, Crown 8vo. (London: Oxford University Press, 1914.) Price 3*d*. net; post free, United Kingdom and abroad, 4*d*.

This is another of the useful series of "Oxford Pamphlets, 1914," of which the title explains itself. It is written by the Librarian of the Royal Colonial Institute, and shows how the Germans came to acquire their African colonies, of which it emphasises the economic value, with the possible but by no means certain exception of German South-West Africa. At present, it is pointed out, all the German colonies in Africa, being plantations rather than colonies in the strict sense of the term, admit of enormous development. The colonies have appealed to the potential German colonist, but the latter, mainly owing to the increasing demand for labour in Germany itself, has only made a modest response.

AN ATLAS OF ECONOMIC GEOGRAPHY. By J. G. Bartholomew, LL.D. With an Introduction by L. W. Lyde, M.A. Pp. lxvi + 64, Demy 4to. (London: Oxford University Press, 1914.) Price 5*s*. net; post free, United Kingdom 5*s*. 5*d*., abroad 6*s*.

This atlas appears opportunely when so much attention is being given to the teaching of geography and especially of economic geography. The maps and charts are clearly printed, and the subjects with which they deal are well selected with a view to showing why and how economic and industrial development has reached its present stage in each of the Continents of the world. The maps may be divided into nine principal sections; the first 27 pages contain maps and charts relating to the whole world, then follow sections dealing with Europe, Europe and the East, Asia, Africa, America, West Indies, etc., Australasia, and finally a series of production maps for the chief commercial products. Among the latter are included a number of important tropical products, such as rubber, coconuts, silk, tea, coffee, cocoa, sago, bananas, oranges, spices, cotton, and hemp, for which production maps are not readily available. On each of these maps a diagram is printed indicating the relative productivities of the various countries concerned, so that the reader can see at a glance the general distribution of the crop over the world and the relative importance of the

productions in the various countries interested. Great pains have clearly been taken to ensure that the information given is accurate, and, so far as our experience of the atlas goes, very few points have escaped attention. It may be mentioned, however, that in the tea map the Caucasus is not marked as a producing region, and similarly the fisheries map omits Cyprus as a sponge-producing area.

Mr. Lyde's introduction consists of a series of short articles written about the maps and charts in the atlas. It is conceived on broad lines, and is both readable and informative.

The atlas, as a whole, is a very creditable production, and its issue at such a low price is a commendable piece of enterprise on the part of the publishers.

BOOKS RECEIVED

JAVA ET SES HABITANTS. By J. Chailley-Bert. 4th éd. Pp. cxlvii + 330, Crown 8vo. (Paris: Armand Colin, 1914.) Price 5 francs; post free, United Kingdom 4*s.* 4*d.*, abroad 4*s.* 5*d.*

LANDS FORLORN: The Story of an Expedition to Hearne's Coppermine River. By George M. Douglas, with an Introduction by James Douglas, LL.D. Pp. xv + 285, Small 4to. (New York and London: G. P. Putnam's Sons, 1914.) Price $4 net; post free, United Kingdom 17*s.* 1*d.*, abroad 17*s.* 8*d.*

SOUTH AFRICAN SKETCHES AND STORIES. "South Africa" Handbooks, No. 79. Pp. 28, Royal 16mo. (London: "South Africa" Offices, 1915.) Price 6*d.*; post free, United Kingdom and abroad, 6½*d.*

MINING WORLD INDEX OF CURRENT LITERATURE, Vol. VI., last half-year 1914. By G. E. Sisley. Pp. xxvii + 234, Med. 8vo. (Chicago: The Mining World Company, 1914.) Price $2; post free, United Kingdom 8*s.* 8*d.*, abroad 8*s.* 11*d.*

DIRECTORY OF PAPER MAKERS OF THE UNITED KINGDOM FOR 1915. Pp. 236, Imp. 8vo. (London: Marchant Singer & Co., 1915.) Price 1*s.* net; post free, United Kingdom 1*s.* 4*d.*, abroad 1*s.* 8*d.*

THE WORLD IN ALLIANCE: A plan for preventing future wars. By F. N. Keen, LL.B. Pp. 60, Crown 8vo. (London: Walter Southwood & Co., Ltd., 1915.) Price 1*s.* net; post free, United Kingdom and abroad, 1*s.* 3*d.*

THE "SOUTH AFRICA" MAP OF SOUTH AFRICA, 1915. (London: "South Africa" Offices, 1913.) Price 1*s.*; post free, United Kingdom 1*s.* 3*d.*, abroad 1*s.* 4*d.* Mounted on cloth 2*s.* 6*d.*; post free, United Kingdom 2*s.* 9*d.*, abroad 2*s.* 10*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

PETROLEUM IN PAPUA

Although important occurrences of petroleum have been known and developed for many years in various parts of the East Indian Archipelago, and it was reasonable to expect that occurrences would be found also in Papua, it was not until late in the year 1911 that the discovery of petroleum in Papua was announced. In that year Messrs. E. McGowan and H. Swanson, who were prospecting for gold, detected the smell of kerosene in the vicinity of the Kiri creek near Opa, about 3 miles from the lower reaches of the Vailala river. This fact was reported verbally to Messrs. G. A. Thomas and L. Lett, two coconut planters, who, as a result of their own observations and enquiries among natives, established the fact of the occurrence of petroleum at various localities, and reported to the Australian Commonwealth authorities their discovery of "a petroleum deposit on the banks of the Vailala river, in the Gulf Division of Papua."

A sample of water (8 oz.) containing iron oxide and greasy matter in suspension was sent to the Geological Survey of New South Wales, and was examined by Mr. J. C. H. Mingaye, the Survey analyst, who obtained from it about 1 cubic centimetre of a heavy oil that appeared to consist of crude petroleum.

The Vailala oil occurrences were examined at a later date by Mr. J. E. Carne, of the New South Wales

Geological Survey, who visited Papua early in 1912, and reported on "Coal, Petroleum, and Copper in Papua" (*Bulletin* No. 1, *Territory of Papua*; published by the Dept. of External Affairs, Melbourne, 1913). Mr. Carne confirmed the discovery of oil and gas near Opa, and other localities in the vicinity of the Kiri creek, and also reported the occurrence of oil at Akauda, some 25 or 30 miles farther up the Vailala river. At this locality, where an oil seepage was found in the bed of a small creek near its junction with the Vailala river, there is a dipping series of alternating sandstone and mudstone beds of Tertiary age, covered by some 10 or 12 ft. of alluvium, and the upper beds of sandstone were found to contain fragmental plant remains.

Mr. Carne found that these Tertiary rocks, and the alluvium overlying them, occupy the whole of the coastal district in the vicinity of the Purari and Vailala rivers, and stretch for a long distance inland. It is in these Tertiary beds in the vicinity of the upper reaches of the Purari river that beds of brown coal occur.

Much important work on the geology of the Vailala oil field has been done by Mr. E. R. Stanley, Government Geologist of Papua, who made a report on the geology of the petroleum area during 1912. The following year Mr. Stanley published a paper entitled "The Papuan Petroleum Area" (*Australian Assoc. for Advancement of Science*, 1913, **14**, 200). In this paper he dealt in a general way with the geology of the oil field, and gave a geological sketch map. He pointed out that the Tertiary beds in the Gulf Division of Papua, in which the oil occurs, are in part folded into anticlines and synclines, and suggested that the folds should be mapped before drilling was undertaken.

During 1913, a sample of crude petroleum obtained from the Vailala oil field was received for examination at the Imperial Institute, and a report was made on the quality of the oil. The sample consisted of about 1 litre of reddish-brown, mobile oil, showing a bluish fluorescence. The oil contained a trace of moisture, and on standing, deposited a slight sediment of clayey matter.

The crude oil as received at the Imperial Institute was examined with the following results:

Specific gravity at 15° C.	0·802
Bromine absorption[1]	3·27
Flash-point (determined by Abel-Pensky closed test)	below 20° C.

[1] *Grams of bromine absorbed by 100 grams of oil.*

The sample contained about 2 per cent. of paraffin wax.

On fractional distillation the crude oil gave the following results:

Fraction.	Description.	Boiling-point.	Yield by volume.	Specific gravity.	Flash-point.[1]	Bromine absorption per cent. by weight.
			Per cent.			
Light petroleum	Water-white	Under 150° C.	32·5	0·758	Under 20° C.	2·91
Kerosene	Lemon-yellow, with bluish fluorescence	150° C. to 300° C.	58·7	0·822	57° C.	2·80
Lubricating oils and solid hydrocarbons	Dark brown, and solid at ordinary temperatures	Over 300° C.	8·8	—	—	—
Coke and asphaltic constituents	—	—	nil	—	—	—

[1] *Determined by Abel-Pensky closed test.*

In order to determine whether the crude petroleum could be used for the production of a fuel oil, the fraction boiling under 150° C. was distilled off, and the residual oil was then examined with the following results:

Calorific value	10,838 small calories.
Flash-point (determined by Abel-Pensky closed test)	57° C.
Bromine absorption	2·5 per cent. by weight.
Condition of oil at 0° C.	Semi-solid.

This residual oil contained only a trace of sulphur, but in other respects it would be unsuitable for use as a fuel oil for Admiralty and marine uses owing to its low flash-point and the fact that it is semi-solid at 0° C., and deposits solid paraffin at ordinary temperatures, such as 20° C. The British Admiralty revised specification for oil fuel (1912) requires that the sample shall have a flash-point not lower than 175° F. (79·5° C.); that the sulphur present shall not exceed 3·0 per cent., or the water 0·5 per cent.; and that the viscosity of the oil shall not exceed

2,000 seconds for an outflow of 50 cc. at a temperature of 32° F. (0° C.) as determined in the Redwood viscometer.

Any attempt to raise the flash-point of this Papuan oil by removing more of the lower boiling fractions by distillation would result in the production of an oil which would be solid even at temperatures above 0° C., and therefore much too viscous for Admiralty use.

Considered generally, the sample represented a valuable type of crude oil, owing to the high proportion of light petroleum and kerosene it contained and the purity of the fractions yielded on distillation. In considering the analyses of samples of Papuan oil hitherto examined, however, allowance should be made for the fact that these samples have been obtained from surface occurrences, or from comparatively shallow borings. The oil obtained at greater depth may show a somewhat different composition.

As regards the products yielded by the crude oil on distillation, these bear a great resemblance to those obtained from crude Sumatra oil, four typical analyses of which are given below (quoted from *A Treatise on Petroleum*, by Sir Boverton Redwood, 1913, vol. i. p. 234):

	Specific gravity of crude oil.	Light petroleum.	Kerosene.	Heavy oil.
		Per cent.	*Per cent.*	*Per cent.*
No. 1 . . .	0·765	22·9	49·1	12·5
No. 2 . . .	0·769	30·0	45·0	16·1
No. 3 . . .	0·777	28·0	49·0	14·5
No. 4 . . .	0·800	27·5	52·5	14·0

A more systematic examination of the Vailala oil field was undertaken on behalf of the Commonwealth Government in the latter part of 1913 by Dr. Arthur Wade, co-operating with Mr. L. L. Wrathall and the Government Geologist of the Territory of Papua, together with a competent staff of surveyors and drillers. The work by this survey party was concluded in August 1914, and a *Report on Petroleum in Papua*, by Dr. Wade, dated 1914, has been issued by the Commonwealth Government. This report deals in some detail with the results of a geological examination of the Vailala oil field, and gives recommenda-

tions as regards the lines upon which development should proceed. Dr. Wade gives sections showing the folded character of the rocks, and is of opinion that the structure of the area is highly favourable for the accumulation of petroleum in many isolated anticlines. The area has been affected by two series of folding movements during Tertiary times. These movements appear to have operated at right angles to each other, and have resulted in the formation of domes and anticlines of the type in which oil reservoirs are frequently found. All the occurrences of oil seepages, and other occurrences that give evidence of the existence of oil, are within 12 miles of the coast.

Although, however, the preliminary geological investigations that have been carried out by various workers have yielded such promising results, the economic importance of the field is as yet doubtful; and it remains to be seen whether, by the adoption of a more ambitious scheme of drilling on favourable sites, the existence of substantial oil reservoirs will be proved.

The Commonwealth Government intends to profit by the experience that has been gained elsewhere. In accordance with the recommendation of the Government Geologist of Papua, extensive drilling operations have wisely been postponed until some knowledge of the geological conditions has been gained. On the basis of such a systematic geological investigation of an oil field, exploitation can proceed more efficiently and with less wastage of resources than has taken place in many fields where geological investigation has been allowed to follow instead of precede exploitation.

COAL FROM SOMALILAND

A SAMPLE of coal, stated to have been obtained from a locality 53 miles east of Berbera and 30 miles south of Karam, was received from His Majesty's Commissioner in Somaliland in February 1915.

It consisted of lumps, varying from about ½ lb. to 5 lb. in weight, of black and fairly compact coal of the sub-bituminous type. The coal had a specific gravity of about 1·3.

Streaks and nodules of iron pyrites were present in some of the lumps.

The coal was examined with the following results:

	Per cent.
Moisture (on drying at 110° C.)	13·01
Volatile matter	35·16
Fixed carbon	39·78
Ash	12·05
Sulphur	0·64
Calorific value	5,661 small calories.[1]

[1] *A small calorie is the amount of heat required to raise the temperature of* 1 *gram of water from* 0° *to* 1° *C.*

The coal burnt freely, without caking, and gave a light cream-coloured ash which did not fuse. The calorific value was about 75 per cent. of that of Welsh steam coal.

The coal much resembled certain samples from Nigeria which have been examined at the Imperial Institute, but was not so good as the better qualities obtained from the Udi-Okana coal field of that country.

The sample was somewhat shaly in appearance, but the ash appeared to be fairly uniformly disseminated through the coal. The proportion of sulphur present could probably be substantially reduced by rough hand-picking.

If the sample now reported on is fairly representative of the coal obtainable from this deposit, the latter can be of no immediate value except for local use, as the coal could not compete even in the nearer Mediterranean and East African markets with better coals available from other sources.

The deposit may, however, be of great economic value to Somaliland later on, and it ought to be thoroughly examined in order to ascertain its extent and the general quality of the coal.

SALT FROM SOMALILAND

The samples of salt dealt with in this report were received from His Majesty's Commissioner in Somaliland in August 1914. They were described as follows:

No. 1.—"Specimens picked up from foot of Dagah Der Hill, 25 miles east of Berbera, 35 miles north-east of Dagah Shabel."

No. 2.—"Pieces chipped from block in Dagah Der Hill through exposed orifice."

No. 3.—"Piece chipped from block in Darroboh Hill through exposed orifice."

The material in each case consisted of compact crystalline salt, which was analysed with the results given below:

		No. 1.	No. 2.	No. 3
		Per cent.	*Per cent.*	*Per cent.*
Sodium chloride	$NaCl$	84·98	94·78	91·30
Sodium bicarbonate	$NaHCO_3$	0·29	0·15	nil
Calcium sulphate	$CaSO_4$	2·17	0·69	3·10
Calcium chloride	$CaCl_2$	0·24	0·47	0·24
Matter insoluble in water[1]		11·87	4·05	4·61
Moisture		0·23	0·19	0·28

[1] *Consisting mainly of calcium carbonate* ($CaCO_3$).

No soluble phosphates, borates, nitrates, iodides or bromides, or ammonia, were detected in the samples.

The soluble portion of these three samples of salt from Somaliland is very similar in composition to most rock salts, except that a small percentage of sodium bicarbonate is present in Nos. 1 and 2. For comparison the following analyses recorded for typical European rock salts may be quoted:

		Cheshire.	Tyrol.	Stassfurt.	Marennes (red).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sodium chloride	$NaCl$	98·30	99·43	94·57	96·78
Calcium chloride	$CaCl_2$	—	0·25	—	—
Magnesium chloride	$MgCl_2$	0·05	0·12	0·97	0·68
Magnesium sulphate	$MgSO_4$	—	—	—	0·60
Calcium sulphate	$CaSO_4$	1·65	0·20	0·89	1·09
Alumina and ferric oxide	Al_2O_3 Fe_2O_3	—	—	3·25	0·85
Water	H_2O	—	—	0·22	—

Refined salt of good quality could be prepared, if desired, from these crude Somaliland salts, by a process of re-crystallisation from water. With reference to the small quantities of sodium bicarbonate present in two of the samples, experiments were made in order to ascertain

whether this impurity could be eliminated easily by recrystallisation. For this purpose equal proportions of samples 1 and 2 were taken and dissolved in 2½ times their weight of water. The solution was allowed to stand, and the clear liquid was then decanted from the insoluble matter and allowed to crystallise at a temperature of about 40° C. Examination of the successive crops of crystals thus obtained showed that if the process was stopped when about 80 per cent. of the total quantity had been recovered, a refined salt was obtained free from sodium bicarbonate, and containing only about 1·2 per cent. of calcium sulphate as impurity.

The refined salt thus prepared was of good colour, and did not deliquesce on exposure to air. Such a salt would be quite suitable for culinary purposes.

BEANS OF *CANAVALIA* SPP. FROM MONTSERRAT AND INDIA

THE question of utilising the seeds of species of *Canavalia* as a feeding stuff for animals has been receiving attention in a number of countries recently. The results of examination of samples of sword beans (*C. ensiformis*) from Honduras and the Gold Coast have already been recorded in this BULLETIN (1913, **11**, 242; 1914, **12**, 549), as well as of samples of *C. obtusifolia* beans from the latter Colony (1914, **12**, 550). Quite recently specimens of sword beans, or "horse beans," have been received from Montserrat, and of the beans of a species of *Canavalia* from Burma. These are dealt with in the following pages:

"*Horse Beans*" (*Canavalia ensiformis*) *from Montserrat*

This sample consisted of flattish oval beans, varying in size from ¾ × ½ in. to ½ × ⅝ in., and about $\frac{5}{16}$ in. thick. The beans were white externally, with a well-marked brown hilum; the interior was yellow, of moderate hardness, and possessed an agreeable flavour.

The beans were analysed with the following results, compared with those obtained for a sample of *C. ensiformis* beans from British Honduras, previously examined at the Imperial Institute:

	Present sample.	*C. ensiformis* beans from British Honduras.
	Per cent.	*Per cent.*
Moisture	12·7	14·4
Crude proteins	26·09	25·0
Consisting of:		
True proteins	20·25	—
Other nitrogenous substances	5·84	—
Fat	3·9	2·7
Starch (by difference)	46·91	48·4
Fibre	7·6	6·8
Ash	2·80	2·7
Nutrient ratio	1 : 2·1	1 : 2·2
Food units	121·9	117·6

No alkaloids or cyanogenetic glucosides were present in the beans.

The above results show that these "horse beans" from Montserrat are very similar in chemical composition to the *C. ensiformis* beans from British Honduras previously examined at the Imperial Institute (*loc. cit.*).

Beans of Canavalia sp. from Burma

A sample of beans of a species of *Canavalia*, known by the native names of "Rar" and "Bu-shol," was received along with the beans from Burma dealt with on p. 196. It was stated that the species had been grown as a fence plant at Natywagon, the original seed having been obtained from Falam in the Chin Hills. According to *Bulletin* No. 12 of 1914, *Department of Agriculture, Burma*, "Rar" or "Bu-shol" is a race of *Canavalia ensiformis*, cultivated to a small extent in the Chin Hills, chiefly in gardens.

The beans were large, white, rounded oblong, varying from 0·9 to 1·2 in. in length, and having a narrow brown hilum about 0·7 in. long. They were clean and in good condition. The results of a chemical examination of the beans, compared with a sample of sword beans from British Honduras, are shown in the following table:

	"Rar" or "Bu-shol," *Canavalia* sp.	Sword beans, *Canavalia ensiformis*, from British Honduras.
	Per cent.	*Per cent.*
Moisture	12·8	14·4
Crude proteins	26·7	25·0
Consisting of:		
True proteins	19·4	—
Other nitrogenous substances	7·3	—
Fat	1·2	2·7
Starch (by difference)	51·1	48·4
Fibre	5·4	6·8
Ash	2·8	2·7
Nutrient ratio	1 : 2	1 : 2·2
Food units	121	117·6

Commercial Utilisation of Canavalia Beans

Canavalia beans are not at present an article of commerce in the United Kingdom, and consequently a market would have to be created for them in the first instance. With this object in view samples of the beans from Montserrat and Burma, together with copies of the analyses, were supplied to merchants, who were asked for opinions as to the possibility of introducing the beans into the United Kingdom.

One firm reported that they had submitted the beans to buyers in various parts of the country, but that the results had not been very encouraging, as there is always some difficulty in introducing a new product of this kind. They stated that if the beans proved to be suitable for use as human food they might possibly realise from £9 to £10 per ton c.i.f. United Kingdom ports (December 1914), but that if they could only be used for feeding purposes their value would not exceed about £6 10*s*. per ton.

A second firm expressed the opinion that it would be possible to find a market in this country for the beans as a feeding stuff, and for this purpose they valued them at £5 per ton c.i.f. London (November 1914).

One of the firms consulted requested information as to the approximate cost of the beans delivered in the United Kingdom, and the quantities likely to be available, and they suggested that a trial shipment of 1 ton of

the beans should be obtained in order to test the market.

Very little is known regarding the actual value of these beans as a feeding stuff for cattle. According to the United States Department of Agriculture (*Bureau of Plant Industry*, *Circular* No. 110, p. 31) *Canavalia ensiformis* beans are indigestible to cattle. Further, the *Rapport Annuel de la Station Agronomique de Maurice* for 1909, p. 53, states that these beans are regarded with suspicion in the island as being poisonous. The report adds, however, that the beans have frequently been eaten and that no actual case of poisoning by them has been recorded in Mauritius. According to a leaflet published this year by the Department of Agriculture, Mauritius, it has now been established on several estates in that Colony that crushed sword beans may be fed to cattle with advantage and that they are eaten readily.

The question of the toxicity of the beans has also been raised in Germany and a large consignment of the beans was sent from German East Africa in 1912 to Germany for feeding trials in order that this point might be definitely settled.

The results of these trials have been published in *Die landwirtschaftlichen Versuchsstationen* (1914, **85**, 1914). Two young sheep were each given 0·44 lb. of the crushed beans daily and apparently suffered no ill effects, but it is pointed out that it would be premature to draw the conclusion that these beans, under all conditions, are a harmless fodder, and it would be advisable to repeat the experiments. The digestibility of the beans, as determined by a four weeks' test on the sheep, was found to be as follows: dry matter 87·5, organic matter 88·6, crude proteins 80·5, crude fat 72·1, carbohydrates, etc., 99·1, and crude fibre 72·9 per cent.

It is understood that the immature beans have been used as a vegetable in the West Indies and elsewhere, and that no untoward symptoms have occurred from their use in this way.

On the whole it seems clear that sword beans are worth extended trials as a feeding stuff for cattle, and

as the plant seems to be particularly suitable for cultivation in various tropical countries it is desirable that such trials should be made as soon as possible.

BEANS FROM BURMA

In a previous number of this Bulletin (1914, **12**, 355) an account was given of the results of examination of samples of peas and beans which had been grown experimentally at the Natywagon Sub-station, Burma. The objects of the experiments were (1) to ascertain the suitability of Madagascar beans ("butter beans") for cultivation in Burma, and (2) the isolation of pure races of native Rangoon beans (*Phaseolus lunatus*) with a view to obtaining beans of this species yielding none or only negligible quantities of prussic acid. As mentioned in the previous article, consignments of Madagascar beans were forwarded by the Imperial Institute to Burma for cultivation, and specimens which had been grown there were examined at the Imperial Institute. These experiments were continued during 1913–14, and a further consignment of Madagascar beans was forwarded to Burma by the Imperial Institute in August 1913 for trial cultivation. Specimens of beans grown in these later experiments, both at Natywagon and at the main station at Mandalay, were received at the Imperial Institute for examination in June of last year; they were as follows:

No. 1. "*Madagascar Beans. Second year's cultivation at Natywagon from seed obtained from the Imperial Institute on* 4/11/12."—Large, creamy white, kidney-shaped beans, which varied in length from 0·7 to 1 in., and were on the whole of dull appearance, with occasional yellow discolorations. The beans were plump, clean, and practically free from insect attack.

No. 2. "*Madagascar Beans. First year's cultivation at Natywagon from seed obtained from the Imperial Institute on* 13/8/13."—Beans similar to those of sample No. 1, but a little more uniform in size, measuring from 0·7 to 0·9 in. in length.

No. 3. "*Madagascar Beans. First year's cultivation on*

Section A of the Mandalay Farm from seed obtained from the Imperial Institute on 13/8/13."—These beans were similar to those of sample No. 2, but were slightly smaller.

No. 4. "*Kawl-be (red), pure line R/a. Mandalay Farm.*" Medium-sized beans of rounded oblong shape, tapering at one end, and approximately 0·4 in. long. They were of uniform purplish-red or brownish-red tints, with faint light-brown specks. The beans were plump, clean, of good appearance, and free from insect attack.

No. 5. "*Kawl-be (red), pure line R/b. Mandalay Farm.*" These beans were similar to those of sample No. 4, but the specks were less apparent.

No. 6. "*Kawl-be (red), pure line R/c. Mandalay Farm.*" Beans similar to those of sample No. 4, but somewhat less plump.

No. 7. "*Kawl-be (red), pure line R/d. Mandalay Farm.*" Beans similar to those of sample No. 4, but slightly larger.

It was stated that samples 1 and 2 from Natywagon were grown on sandy loam, and samples 3, 4, 5, 6, and 7 from Mandalay Farm on stiff black clay.

The three samples of Madagascar beans, Nos. 1, 2, and 3, were compared with specimens of the seed beans from which they were derived. In each case the beans were found to be inferior to the original seed beans in colour, appearance, size, and weight, although there was practically no difference in plumpness except in the case of sample No. 3. The deterioration in size of No. 1 has however taken place chiefly during the second year's cultivation, since the first year's crop was only slightly inferior to the seed beans in size and colour (cf. sample No. 1 in previous report, *loc. cit.*, p. 357). The deterioration in size and weight is specially dealt with in the *Report of the Mandalay Agricultural Station for* 1913–14, pp. 43–45, where it is pointed out that after two years' cultivation the beans (No. 1) deteriorated 39·14 per cent. in weight, whilst sample No. 2 had deteriorated 42·31 per cent. in weight after one year's cultivation as compared with the original seed.

All the samples were submitted to chemical examination in order to ascertain in the first instance the percentages of prussic acid which they yielded. The amounts,

expressed on the beans as received at the Imperial Institute, are shown in the following table:

Sample.	Variety.	Yield of prussic acid.
		Per cent.
1	Madagascar beans	0·008
2	"	0·008
3	"	0·007
4	Kawl-be (red) R/a	0·037
5	" R/b	0·038
6	" R/c	0·036
7	" R/d	0·034

With regard to the Madagascar beans, it is of interest to compare the amounts of prussic acid yielded by the seed beans with that given by the beans grown from them in Burma:

	Seed beans supplied by Imperial Institute, 4/11/12.	First crop in Burma, No. 1 in previous report (this BULLETIN, 1914, **12**, 357).	Second crop in Burma. No. 1 in present report.
Prussic acid, *per cent.*	0·0025	0·005	0·008

	Seed beans supplied by Imperial Institute, 13/8/13.	First crop in Burma, Nos. 2 and 3 in present report.
Prussic acid, *per cent.*	0·002	{0·008 grown at Natywagon. 0·007 " Mandalay Farm.

It will be seen that two crops of beans have been raised in Burma from the seed beans supplied by the Imperial Institute in 1912, and that these crops show a progressive increase in the amount of prussic acid yielded by the beans. The beans of the second crop yielded 0·008 per cent. of prussic acid, as against 0·0025 per cent. in the original seed beans. This increase is contrary to the effect generally produced by cultivation, and it will be interesting to ascertain whether the third year's crop again shows a further increase in the yield of prussic acid, especially as 0·008 per cent. appears to be the largest yield hitherto recorded for Madagascar beans. In samples 2 and 3 the yield of prussic acid has risen from 0·002 per cent. in the seed beans to 0·007 and 0·008 per cent. in the first year's crop. The amount of prussic acid in this case is therefore practically the same after one year's cultivation as in the case of sample 1 after two years. This result suggests that the

season during which the present samples of beans were grown may have been particularly favourable to the production of cyanogenetic glucosides.

The four samples of red Kawl-be beans are all less cyanogenetic than the previous sample examined at the Imperial Institute (*loc. cit.*, p. 358), which yielded 0·05 per cent. of prussic acid, as compared with 0·034 to 0·038 per cent. from the present samples.

Samples Nos. 1 and 4 were also submitted to complete chemical examination in order to determine their composition, and the results are given in the following tables in comparison with the figures for beans of similar character.

Sample No. 1.—Madagascar Beans.

	Madagascar beans. No. 1.	Haricot beans.
	Per cent.	*Per cent.*
Moisture	12·5	14·0
Crude proteins	25·7	23·0
Consisting of:		
True proteins	22·8	—
Other nitrogenous substances	2·9	—
Fat	0·9	2·3
Starch (by difference)	53·9	52·3
Fibre	3·4	5·5
Ash	3·6	2·9
Nutrient ratio	1 : 2·2	1 : 2·5
Food units	120	116

Sample No. 4.—Kawl-be (red).

	Kawl-be (red). No. 4.	Red Rangoon beans.
	Per cent.	*Per cent.*
Moisture	9·5	11·8
Crude proteins	15·3	20·0
Consisting of:		
True proteins	13·8	—
Other nitrogenous substances	1·5	—
Fat	1·2	1·4
Starch (by difference)	64·7	59·1
Fibre	5·1	4·0
Ash	4·2	3·7
Nutrient ratio	1 : 4·4	1 : 3·1
Food units	106	113

The Madagascar beans (Nos. 1, 2, and 3) were submitted for valuation to merchants in London who stated that the beans, especially those of sample 3, were rather small, and that it would depend upon the taste of the public

whether they could be as easily marketed as those grown in Madagascar, which are larger and whiter. In normal times Madagascar beans are sold in London at from 16*s.* to 20*s.* per cwt., but owing to the war, prices are much higher at present (February 1915). The merchants stated that consignments represented by samples Nos. 1 and 2 would probably fetch 26*s.* to 28*s.* per cwt. in London in the present exceptional circumstances, but that a lower price would have to be accepted for sample 3 on account of the smaller size of the beans.

BANANA MEAL FROM JAMAICA

In view of the present high price of wheat flour attempts are being made in the British West Indies to replace part of the flour imported by locally prepared products. Of these the chief attention has been paid to cassava flour and banana meal. In this connection a sample of the latter from Jamaica was received at the Imperial Institute with a view to determining its composition in comparison with that of wheat flour. It was stated that the sample represented a type of meal which could be made generally in the Colony.

The sample consisted of a finely ground meal, of light sandy colour, and possessing a rather pronounced aroma. It was examined with the following results, compared with the results of analyses of two samples of banana flour from Seychelles examined at the Imperial Institute, and of wheat flour and maize meal :

	Present sample.	Banana flour. (1) Orange.	Banana flour. (2) Grey.	Wheat flour.	Maize meal.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	12·0	9·8	11·1	11·9	11·1
Crude proteins	4·6	3·4	4·8	13·6	9·5
Consisting of :					
True proteins	2·3	2·4	3·5	—	—
Other nitrogenous substances	2·3	1·0	1·3	—	—
Fat	0·6	0·3	0·4	1·3	6·2
Starch, etc. (by difference)	79·6	84·2	80·8	72·6	70·6
Fibre	0·7	0·5	0·5	0·1	1·4
Ash	2·5	1·8	2·4	0·5	1·3
Nutrient ratio	1 : 17·6	1 : 25	1 : 17	1 : 5·6	1 : 9
Food units	93	93	94	117	110

It will be seen that this sample of banana meal from Jamaica was generally similar in composition to specimens of banana flour which have been examined at the Imperial Institute. The only noteworthy difference between the figures obtained for the present sample and those for the specimens of banana flour quoted in the above table is that the "crude proteins" in the Jamaica meal include an unusually large amount of "other nitrogenous substances" (probably amides), which are inferior to the "true proteins" in food value. The large percentage of amides present may be due to the degree of maturity of the fruits from which the meal was prepared.

Compared with wheat flour or maize meal this banana meal contains a smaller percentage of proteins, and its nutritive value is consequently lower. Maize meal also contains much more fat than the banana meal. The percentage of mineral matter is, however, higher in the banana meal than in either wheat flour or maize meal.

It will be evident from these results that the banana meal will not compare in nutritive value with either wheat flour or maize meal, but nevertheless it should prove useful locally as a partial substitute for these products.

BROOM CORN "BRUSH" FROM NYASALAND

The broom corn or broom millet is a variety of *Sorghum vulgare*, the species to which kaffir corn, dura, sugar sorghum, etc., belong, and is characterised by bearing seed heads with very long, straight branches which constitute the "brush," employed in the manufacture of brooms. The plant is cultivated on an extensive scale in the United States, Italy, and elsewhere, and is also grown on a commercial scale in New South Wales. It has been cultivated experimentally in the British West Indies and in Nyasaland, and three samples of "brush" from the latter country have been examined recently at the Imperial Institute. The samples were grown at the Government Farm, Zomba, from American seed.

The first two samples were received in October 1913, and were as follows:

"*A. Taken before the seed was ripe.*"—The sample had a total length of 2 ft., the stem measuring 6 in. and the brush 1 ft. 6 in. It was mostly of a greenish colour. Some seed vessels were still adhering to the brush.

"*B. Taken by removing the ripe seed.*"—This sample had also a total length of 2 ft., the stem measuring 6 in. and the brush 1 ft. 6 in. In colour it was partly reddish and partly of a deep straw tint. Some seed vessels were still present.

Sample B was better grown than sample A, but was darker in colour, whilst both A and B were shorter and finer in the brush than the ordinary broom corn of commerce.

The samples were submitted to a London firm of importers of brush fibres, who reported that the material would be suitable for making brooms and was similar to the product known as Italian "whisk," the current value of which was about 4*d.* per lb. delivered in London (December 1913).

The firm stated that broom corn fibre should be of a yellow or golden colour, and they were of opinion that the Nyasaland material could be obtained of this colour if it were cut at the right season. They expressed a desire to be put into communication with exporters of the product in Nyasaland.

The third sample was received in February 1915. The whisks varied in total length from 17½ to 30 in., with an average of 25 in. The stem measured from 4¼ to 10½ in. with an average of 5½ in., and the average length of the brush was about 20 in. Many seed vessels were present. The colour was partly reddish, partly deep straw, and partly greenish-yellow. The sample somewhat resembled the previous specimen "B" above, but more seed vessels were present, and the material was slightly less red in colour and somewhat stouter, whilst the brush was slightly longer and coarser. It was submitted for valuation to the firm referred to above, who stated that such material would be readily saleable in London.

It was pointed out in the report on the first two samples that broom corn when prepared for the market should not have more than 2 to 3 in. of stem, whilst the brush should be straight, of uniform length, and composed of stiff stout stalks, preferably of a golden yellow colour. There appears to be a fair prospect of marketing the Nyasaland product in London if it can be prepared in accordance with these conditions.

SPECIAL ARTICLE

THE FIELD AND FOREST RESOURCES OF BRITISH GUIANA

BY

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Situation and Extent

BRITISH GUIANA lies between latitudes 0° 41′ N. (source of the Essequibo river) and 8° 33′ 22″ N. (Punta Playa), has a depth from north to south of about 500 miles, a seaboard of about 270 miles trending in a south-easterly direction, and occupies in the north-east of South America an area approximately equal in extent to Great Britain. It is bounded on the north by the Atlantic Ocean, on the east by Surinam or Dutch Guiana, on the south and south-west by Brazil, and on the west by Venezuela.

The colony may be divided broadly into three belts: The northern one consists of a low-lying flat and swampy belt of marine alluvium—the coastal region. This rises gradually from the seaboard and extends inland for a distance varying from 5 to 40 miles. It is succeeded by a broader and slightly elevated tract of country of sandy and clayey soils. This belt is generally undulating, and is traversed in places by sand-dunes rising from 50 to 180 ft. above sea-level. The more elevated portion of the colony lies to the southward of the above-mentioned

regions. It rises gradually to the south-west, between the river valleys, which are in many parts swampy, and contains three principal mountain ranges, several irregularly distributed smaller ranges, and in the southern and eastern parts numerous isolated hills and mountains. The eastern portion is almost entirely forest-clad, but on the south-western side there is an extensive area of flat grass-clad savannah land elevated about 300 ft. above sea-level.

Area and Population

There are estimated to be 57,770,000 acres of land in British Guiana, of which only about 2,000,000 acres are alienated from the Crown. The remainder is open for beneficial occupation, and it is estimated that of this vast area over 9,000,000 acres are easily accessible. The major portion of the easily accessible area is suitable for the cultivation of many tropical products.

The population is at present estimated to be 304,149, and consists of British, Portuguese, Blacks and their descendants, East Indians, Chinese, and Aboriginal Indians. The population is distributed among the various races in the following proportions:

Europeans	14,000[1]
East Indians	130,000
Chinese	2,600
Aboriginals	7,000
Blacks	115,400
Mixed and others	35,000
	304,000

[1] *Including* 10,000 *Portuguese.*

The greater proportion of the East Indians are associated with the sugar estates, and with cultivations such as rice on the coastal lands; while the forest industries and gold and diamond mining are to a large extent carried on by persons of the African race.

Climate

British Guiana has been at times described as an unhealthy colony. This is an undeserved calumny, as is clearly shown by the statistics of mortality of European races other than Portuguese. For those who lead regular

lives and do not expose themselves to unnecessary risks the climate is decidedly a healthy one. The coastlands are swept throughout the year with the north-eastern trade winds, which add greatly to the comfort, vigour, and health of those resident thereon.

Rainfall.—The mean annual rainfall near the coast is about 94 in., and further inland about 105 in.

The distribution of the rainfall is fairly even; on the coastlands from the month of August to the month of November it is usually drier than at other periods of the year, the precipitation amounting during these months to an average per month of about 2·5 in. Away from the coast the distribution is more even, and in the forest regions there is no marked dry spell. In the savannah country of the hinterland, the far interior of the colony, the rainfall is less regular; there the average annual precipitation amounts to 55·0 in., the period from November of one year to March the following year being usually very dry.

Temperature.—The average mean shade temperature at or near the coastlands for the past twenty-two years is 80·0° F. The average mean maximum is 85·1° F., and the average mean minimum 74·9° F. The greatest annual range is about 19° F.

Recent comparative records of air temperature at three representative recording stations—Georgetown (coastland), H.M. Penal Settlement (Mazaruni River, 42 miles direct from the coastland), and Dada-nawa (in the Rupununi district, 280 miles from Georgetown, in the far interior of the colony)—are shown in the following table:

Station.	Average annual shade temperature.	Mean maximum.	Mean minimum.
Georgetown . . .	80·4° F.	85·7° F.	74·7° F.
H.M. Penal Settlement .	79·7° „	83·2° „	76·4° „
Dada-nawa . . .	82·6° „	92·2° „	72·3° „

Soil

The results of the examination of the various parts of the colony and of the soils characterising them have shown that it must be divided into three great belts, each of which has its own special economic resources.

The belts are as follows:

(1) The alluvial coast belt is an agricultural one of very exceptional fertility, and its soils are probably among the richest and most fertile in the tropical parts of the world. It is well suited for many forms of tropical agriculture.

(2) The widespread belt of the lower hills and plains is covered with a seemingly inexhaustible forest containing many kinds of trees which yield timbers and other products of commercial value. As far as has been ascertained its soils are mainly sedentary ones—the decomposition-products *in situ* of its country rocks—and are of lower agricultural value than those of the agricultural coast belt. It has, however, been shown that on the more promising soils on the lower parts of the belt arboricultural crops, such as limes and Para rubber, can be successfully grown. The regularity of the rainfall in these situations forms an important factor in the cultivation of certain tropical products.

(3) The savannah belt at present is practically undeveloped, but may in time become a great district for cattle-ranching, whilst there are in it belts of alluvial and fluviatile soils of from fair to high fertility upon which many tropical products could be successfully raised.

Land Tenure and Value

The principal terms and conditions on which land may be leased from the Crown for the cultivation of permanent crops, such as rubber, citrus fruits, coconuts, etc., are as follows:

No rent is payable during the first five years of the lease, but the lessee pays an annual rent of 25 cents an acre from the sixth to the tenth year inclusive, and an annual rent of 80 cents an acre during the remainder of the lease; and in default of payment of such rent on the day on which the same is due, the lessee, in addition, pays interest thereon at the rate of 6 per cent. per annum for each day of such default.

The lessee shall each year plant not less than one-twenty-fifth part of the land leased until he has so planted not less than seven-twenty-fifth parts of the said land, and

shall maintain such cultivation in good order to the satisfaction of the Governor-in-Council, or of such officer as may be from time to time deputed by the Governor-in-Council to inspect the cultivation.

During the continuance of the lease the lessee shall pay the sum of 2 cents (1*d.*) a pound for all rubber, balata, or other substances of a like nature obtained by him from the land, *from indigenous* trees. There is no royalty on produce of planted trees.

The fees payable for obtaining a lease, which must be deposited with the application, are as follows:

Application	$5.00
Survey:	
Areas up to 500 acres . . . *per acre*	0.30
Each acre above 500 and up to 1,000	0.20
Each acre above 1,000	0.10

These charges include labour, cutting lines, etc.

The lessee is also required to pay the cost of drawing up, executing, and stamping the lease in the Registrar's Office, say $16.20.

For the cultivation of other products no Crown land, unless under special circumstances, is sold or granted, but is rented under leases for terms of ninety-nine (99) years or under with a right of renewal, if the conditions attached to such titles have been strictly complied with, for one similar period, subject to a re-assessed rental.

The rents to be charged for such land will, ordinarily, be as follows:

For any area up to 5 acres, $1 per annum.

For areas over 5 and up to 100 acres at 20 cents per acre per annum.

For areas over 100 and up to 500 acres at 15 cents per acre per annum.

For areas above 500 acres at 10 cents per acre per annum.

These conditions compare very favourably with those of other tropical countries.

Labour

In 1911, when the last census was taken, 70,922 or 24 per cent. of the total population was engaged on

sugar estates; the demand for a large supply of labour for the sugar industry has made immigration from India a necessity for its successful operation.

Immigration from India commenced in 1838, but it was not until 1845 that regular immigration, recognised by the Government, began. From 1901 to 1911 the average annual immigration of East Indians was 2,435. The colony is now divided into Immigration Districts, each in charge of a resident Agent, while the medical care of the immigrants is under the charge of the Medical Department. In addition to indentured East Indians, the sugar estates employ both East Indians who have served their period of indenture and Blacks. The wages on sugar estates for field operations vary from 1*s.* to 2*s.* a day, cane-cutters earning higher wages, 1*s.* 6*d.* to 3*s.* 6*d.*; a day's work for the indentured East Indian is defined by law as one of 7 hours. Those engaged in the manufacture of sugar earn higher wages, generally speaking from 1*s.* 6*d.* to 2*s.* 6*d.* per day.

The labour employed in other cultivations consists of East Indians and Blacks, with some Aborigines. Wages for men vary from 1*s.* 4*d.* to 2*s.* per day; women earn 10*d.* to 1*s.* 0½*d.*, and children 6*d.* to 8*d.*

Agricultural Industries

The chief agricultural crops are sugar, rice, coffee, cacao, coconuts, rubber, limes, and "provisions," such as plantains, cassava, tannias, yams, sweet potatoes,[1] etc. Of these the principal exports are sugar and its by-products—rum, molasses, and molascuit—rice, coffee, and coconuts. Large increases have recently taken place in the exports of coffee and rice.

The front portion of the coastal region is in part occupied by sugar estates, whilst the bulk of the rice is grown upon this section of the colony. Provision-grounds are situated at the back of the sugar estates, at the back of the coastal village lands, and on the lower reaches of rivers. Coconuts are grown on the coastal region, while cacao and coffee are chiefly cultivated on the river lands in their

[1] Specimens of most of these products and of others mentioned in this article may be seen in the British Guiana Court of the Public Exhibition Galleries of the Imperial Institute. [Ed.]

lower reaches. Rubber is being successfully cultivated on the river lands, and also on the slightly elevated tract of country immediately behind the coastal region.

Cattle raising is carried on to a large extent on the very extensive flat pasture land of the coastal region, and on a smaller scale on the savannahs of the hinterland.

Sugar

The sugar-cane with its products is the most important of the agricultural resources of the colony. The sugar industry of British Guiana, in common with that of the West Indian Islands and of some other countries, has passed through many vicissitudes during the last quarter of a century. But the industry has fairly well held its own in the face of prices which at times have been so low as to be more or less unremunerative, and of seriously lessened yields in places owing to the sugar-cane having become in them subject to disease to an extent not previously experienced. The area of land, about 72,000 acres, under this crop is practically the same as it was eighteen years ago, while the average crops of sugar-products are somewhat higher. In round figures the colony exports in normal years about 110,000 tons of sugar, 3,600 casks of molasses, 2,500,000 gallons of rum, and 12,000 tons of cattle-food prepared from the refuse-products of the sugar-cane. But if scarcity of labour did not stand in the way of the expansion of the sugar industry, the colony would be able to produce many times the quantities of sugar-products for which it is now responsible.

Should any certainty arise of sugar continuing to command, as at the time of writing, remunerative prices, a very great extension of sugar cultivation would take place in the colony. It is estimated on very conservative grounds that the readily available area of land well suited for sugar-cane cultivation in the eastern part of the colony could produce 1,000,000 tons of sugar, whilst there is available land suitable for sugar cultivation in the north-western portion of the colony to increase this amount to 2½ million tons a year.

As in many other sugar-cane producing countries, the

sugar-cane in British Guiana has suffered much in late years from fungoid diseases. The Bourbon, which was the best variety cultivated and the source of the far-famed "Demerara Crystals," has either developed a certain tendency to disease or lost to a marked extent the resisting powers to fungoid attacks it once possessed, and thus has fallen off in yield. When the Bourbon cane first showed signs of tendency to disease, the planters of the colony took the matter seriously in hand, and succeeded more or less in keeping the diseases under control by the adoption of, as far as possible, every precaution that was suggested by the authorities at Kew, or was indicated by their own experience. But they were not as successful as they would have liked to have been, and hence had to resort to attempts to obtaining an equally satisfactory variety from seed, with the result that now more than four-fifths of the area under sugar-cane is in varieties other than the Bourbon.

As far as obtaining varieties which yield more heavily than the Bourbon now does, or which give remunerative crops on land on which that variety has never flourished, these endeavours have been attended with a large measure of success. But a variety which approaches the Bourbon as a source of "Demerara Crystals" has not yet been secured. This sugar does not owe its high reputation solely to the high proportion of sugar it contains, but to its pleasing colour, flavour, and especially to its aroma. The first of these has been more or less successfully imitated in "Yellow Crystals," but the other qualities appear to be unattainable artificially in the perfection which characterises "Demerara Crystals" made from the Bourbon cane. This sugar is a special product of the colony, and when made in British Guiana it may be said to be a "vintage" product of the Bourbon cane.

The trials in British Guiana have had for their object securing or producing reliable varieties of sugar-cane from which planters may select kinds to suit their special conditions of soil, rainfall, etc., and this has been more or less successfully accomplished. In the year 1899 only 550 acres were planted in new varieties in the colony, whilst at the

present time over 55,000 acres are under them. The records show that certain new varieties of sugar-cane have given over large areas mean results 30 per cent. higher than the returns obtained from the Bourbon on the same plantations. About 14 per cent. of the area occupied with new varieties is under kinds imported from Barbados, whilst about 85 per cent. is under kinds raised in British Guiana. The most promising varieties up to the present are 208 B. and 147 B., imported from Barbados, and D. 625, Diamond 185, D. 118, and D. 145, raised in Demerara.

The sugar-manufacturing industry has been compelled by economic conditions to develop into one almost solely for large capitalists and companies. Smaller cultivators pursue the sugar-cane-growing industry with fair success. Cane-farming is carried out to some extent by small proprietors and villagers, and its extension on a mutually profitable basis to the farmers and to the manufacturers is very desirable.

The following tables show the average annual quantities and the values of sugar and sugar-products exported from British Guiana during the quinquennial periods from 1892 to 1911 and the years 1912, 1913, and 1914:

Quantities

Period.	Sugar. *Tons.*	Rum. *Proof gallons.*	Molasses. *Gallons.*	Molascuit. *Tons.*
1892–6	106,257	2,003,885	100,852	—
1897–1901	96,542	4,062,034	357,201	—
1902–6	116,859	3,535,057	333,366	6,666
1907–11	104,961	2,939,623	176,288	8,488
1912[1]	77,788	2,382,937	176,011	5,116
1913[1]	87,414	3,260,986	118,699	6,860
1914	107,138	3,489,729	83,197	2,427
Mean	99,565	2,925,055	192,242	5,911

[1] *Crops very adversely affected by the prolonged droughts of* 1911 *and* 1912.

Values

Period.	Sugar. £	Rum. £	Molasses. £	Molascuit. £
1892–6	1,305,989	135,946	24,965	—
1897–1901	1,066,376	189,186	11,070	—
1902–6	1,142,284	107,099	11,070	23,679
1907–11	1,170,399	134,690	11,447	20,300
1912	1,019,490	126,178	7,494	17,145
1913	1,102,670	204,163	5,020	23,490
1914	1,574,615	321,846	4,284	10,246
Mean	1,179,218	147,699	13,449	18,972

The average value of the products of sugar-cane exported annually from the colony for the past twenty-three years has been £1,361,195.

In the nineties two-thirds of the British Guiana sugar were exported to the United States and almost one-third to the United Kingdom, only a small quantity going to Canada; whilst in 1912 and 1913 70 per cent. of the sugar was exported to Canada, about 20 per cent. to the United Kingdom, and 8 per cent. to the United States.

Rum

British Guiana has the largest export of rum of all the West Indian colonies, its export of pot-still rums alone being 12 per cent. higher than that of Jamaica. The production of rum has been the subject of investigation in British Guiana on scientific lines for many years past, and as far as the production of alcohol from the sugars present in the wash (wort) is concerned, it has in many estate distilleries been brought to a condition approaching perfection.

In British Guiana rum is produced by a rapid fermentation extending from 36 to 48 hours by setting up a wash of molasses diluted with water at a density of about 1·060. The wash is set up slightly acid, and in some distilleries small quantities of sulphate of ammonia are added to it in order to supply readily available nitrogenous food for the yeast.

The distilleries are of two types, using either pot or vat-stills, or Coffey and other continuous rectifying stills. In 1914 there were 27 distilleries of the first type and 9 of the second. The Coffey or continuous rectifying stills used are of well-known types and are usually built locally, their columns being constructed of colony-grown timber.

Demerara rum is the product of a pure yeast fermentation, and hence does not possess a high flavour like rums of slower fermentation, where wild yeast and bacterial organisms flourish in the wash.

Molascuit

About a dozen years ago Mr. George Hughes, F.C.S., introduced a process for the preparation from the by-product of the sugar-cane of a high-grade cattle food, especially suited for the rapid fattening of beasts. The food consists of a mixture of the finer particles of the interior spongy tissues of the sugar-cane, which is separated from the megass produced during the grinding of the sugar-cane in the manufacture of sugar, with vacuum pan molasses. The mixture results in a dry, brown coloured, coarse powder possessing a very fragrant and attractive odour. Its special characteristic is the relatively high digestibility of the fibre present in the food. Representative samples have the following percentage composition :

Moisture	17·3
Fat	0·6
Albuminoids	1·5
Sucrose	36·1
Glucose	20·2
Other soluble carbohydrates	7·3
Digestible fibre	7·6
Woody fibre	2·9
Mineral matters (ash)	6·3

The high proportion—72 per cent.—of readily digestible constituents in molascuit is clearly shown in the above. For use as a cattle food it should be fed with an addition of another feeding stuff, such as cotton-seed cake, containing relatively high proportions of albuminoids and fat.

Rice

This industry is one pursued by small farmers, and its development in the colony has been mainly due to the East Indian settlers. The black people in the colony also enter with some enthusiasm into this industry. The proprietors of sugar estates give every facility in their power to their employees to carry on rice growing.

The returns made to the Board of Agriculture show the great extension which has taken place in this industry during recent years. In 1898 the acreage returned by

cultivators as being under rice was about 6,000 acres, for 1914 it was returned as about 45,000 acres.[1] The increase in the crop of rice between 1899 and 1915 represents about 32,000 tons of cleaned rice per annum, the value of which probably is about £450,000.

The enormous area in British Guiana pre-eminently suitable for the cultivation of rice should enable this colony to become the granary for the West Indian Islands.

The rice generally grown in the colony is a long-grained variety known as Creole rice, and seems to be one which has originated there by unconscious selection. It is of excellent quality, equal to any that has been imported into the colony. The choicest strain of the Creole rice is that known as the "Berbice." It has been proved that by experimental cultivation we can obtain varieties of equally good quality but of higher yielding powers.

With this object in view large numbers—over 250—of varieties of rice have been imported into the colony by the Board of Agriculture. Of these varieties three have consistently given better returns than the Creole has done, and about 10 tons annually of specially selected seed paddy is being distributed free to numerous growers in the colony. Further selections and crosses are being made year by year, and the selected varieties are tried in trial plots against the standard kinds. The results of these experiments are most encouraging. Some of the selected varieties raised during the past few years show, on small plots, marked increases in yields over the standard varieties and are now being tried experimentally over larger areas.

The methods of cultivation generally in vogue are Eastern ones. Nearly the whole of the work is done by hand labour. Primitive ploughs and harrows are employed in many districts, and cattle are sometimes used for the trampling out of the grain, while winnowing is usually accomplished by hand. Improvements in the methods of cultivation are being made, and increased returns have resulted. Rice is being cultivated and reaped on a large scale by modern appliances in the Abary district, and the

[1] As two crops are reaped each year in certain districts, the actual area of rice reaped in 1914 was 51,260 acres.

venture is full of interest as promising, on account of the low cost of production, to be very successful.

There are several large rice mills in different parts of the colony, whilst there are a very large number of small ones scattered throughout the rice districts. From trials made it has been ascertained that locally grown paddy gives about 60–65 per cent. of its weight of clean rice. Two kinds of rice are made; a brown rice in which the paddy is steamed before it is passed through the mills, and a white rice. "Brown" rice is more nutritious than the "white" rice. No polishing of rice is carried out. Rice-meal is made as a by-product, and in 1914 240 tons were exported.

The following table gives the average yield of paddy (unhusked rice) per acre in the colony from 1898 to 1914:

Period.	Average yield of paddy per acre.
	Cwts.
1898–1902	20·7
1903–7	23·3
1908–11	23·3
1911–14	21·8
Mean	22·2

Coconuts

Coconuts thrive well on the coastal lands of the colony, especially where the land is more or less of a sandy nature, and expansion of this cultivation is steadily taking place.

The coconut palms growing in the colony are scattered, being owned chiefly by small growers, but there are a few fair-sized coconut estates; whilst extension over large areas is taking place on some sugar plantations. Reefs of light sandy loam exist on the Corentyne Coast, along the east coast of Demerara, and in Essequibo, where coconuts flourish, and even on the heavier coastal lands they grow satisfactorily and bear very heavily. They do not grow so well or yield satisfactorily on the pegassy-clay lands and on river lands away from the coastal region.

The area planted with coconut palms has been slowly increasing for some years, but during recent years there has been much greater activity in this direction, and the

continued extension of the industry may be expected. The following acreage returns of the Board of Agriculture show the advance that is being made:

	Acres.		Acres.
1904–5	5,140	1910–11	9,761
1905–6	6,560	1911–12	12,236
1906–7	6,700	1912–13	13,698
1907–8	6,828	1913–14	14,177
1908–9	8,315	1914–15	15,260
1909–10	9,466		

A very large proportion of the acreage under coconuts in the colony is still young and has not come into bearing.

The exports of coconuts are at present very small in relation to the number of acres in bearing, as the major portion of the nuts yielded by these areas is utilised in the colony for the preparation of coconut oil and of cattle food. There is a very large consumption of coconut oil especially among the East Indian section of the community, and the locally prepared product has gradually replaced the imported coconut and other kinds of oil. During late years, however, the exports of coconuts have been increasing. This is due to the enhanced value of coconuts in the world's markets, which has rendered the exportation of nuts somewhat more profitable than the preparation of oil for local consumption.

The following table shows the annual average exports during quinquennial periods since 1892:

Period.	Average annual exports. Nuts.
1892–6	80,374
1897–1901	21,892
1902–6	187,305
1907–11	526,901
1912–14 (3 years only)	1,427,644

Coconuts are chiefly exported to the United States. A small quantity of copra is made in the colony, the exports during 1914 being 1,690 cwts. The copra is the ordinary grade used for the extraction of oil, and is mainly sun-dried, although attempts are being made at artificially drying.

Open coppers for boiling the grated coconuts are

generally used in the colony for obtaining the oil, but the returns are not as high as they should be. There are a few oil factories in the colony.

Coffee

In the earlier part of the last century British Guiana, and especially the county of Berbice, was celebrated for the high quality of the coffee it produced. Unfortunately, about the time of the cessation of slavery, circumstances beyond the control of the planters necessitated the gradual abandonment of the cultivation.

At the present time about 3,800 acres are occupied in coffee cultivation, a large proportion of the product being consumed locally. Two kinds of coffee are cultivated in the colony, the Arabian or so-called Creole kind, and the Liberian variety. Both sorts grow with exceptional vigour, and the former is singularly free from disease.

Large areas of low-lying land in British Guiana are ideally suited to the growth of Arabian coffee. The meteorological conditions of these parts of the colony are very similar to those of the higher parts of many of the West Indian Islands, and when this is borne in mind the excellent way in which coffee grows on them ceases to be surprising.

It is greatly to be regretted that local conditions, especially scarcity of available labour, tend to restrict the extension of the area under cultivation, and that the usually low price of coffee does not offer much inducement for small capitalists to take up its cultivation.

The Liberian variety grows very well indeed in many parts of the colony, and wherever it flourishes it is very prolific; in fact, at times the difficulty is to restrain its bearing propensities sufficiently to prevent the tree permanently injuring itself. It is, however, on the wind-swept parts of the coastlands more adversely affected by unfavourable meteorological conditions than is the Arabian kind. But this is not the case at some distance back from the coast-line and on the lands along the lower reaches of the rivers.

The annual exports of coffee during recent years may be seen from the following statement:

	Cwts.		Cwts.
1907	2	1911	1,225
1908	190	1912[1]	727
1909	1,122	1913[1]	798
1910	978	1914	2,132

[1] *Crops affected by the prolonged drought of* 1911 *and* 1912.

Cacao

Cacao-planting is an industry of some promise in parts of the colony, but unfortunately it requires for its successful installation command of more capital than small farmers usually possess. Cacao requires for its satisfactory growth land well drained to the depth of from 3 to 5 ft., and on land of this sort it does very well indeed. There are great areas of land a few miles up the lower reaches of the rivers, where good drainage can be easily ensured, and upon them cacao flourishes. It is to be regretted that persons with command of sufficient capital and with knowledge of the cultivation of cacao have not taken up its growth in these parts of the colony to a greater extent than has been done.

Some of the cacao estates are of fair age, but there are also considerable areas under young trees that have not yet come into bearing. The Government have an experimental area of cacao at Onderneeming, Essequibo, where from selected trees of high yield and good quality seeds are obtained for propagating purposes and increasing numbers of promising cacao seedlings are being supplied at low cost. Systematic experiments with cacao were commenced at Onderneeming in 1900. They have proved of value to the cacao cultivators in the colony by indicating that largely increased yields are obtainable by the reduction of the shade trees to the minimum necessary for protection of the cacao trees against wind, that large increases in yield result from heavily mulching the trees, and that the most profitable applications of artificial manures are of mixtures of sulphate of potash and superphosphate of lime, to which additions of nitrogenous manures are seldom

remunerative, whilst nitrogenous manures *per se* tend to reduce the bearing powers of the trees.

The acreage under cacao cultivation during recent years is as shown below:

	Acres.		Acres.
1907–8	1,832	1911–12	2,127
1908–9	2,181	1912–13	1,983
1909–10	2,223	1913–14	1,863
1910–11	2,016	1914–15	2,316

The decreases in the area returned as cultivated in cacao in the years 1912 and 1913 were attributed to the drought of 1911 and 1912, and to the abandonment of cacao in some cases for rubber cultivation. Practically only the Forastero variety is grown in British Guiana, other sorts being cultivated only to a very small extent.

At present therefore only about 2,000 acres are planted in cacao; their yield is mostly used for the local demands of the colony, and thus the export is small—not more, as a rule, than from 750 to 900 cwts. per annum. That exported brings a good price, owing perhaps to the great care which is exercised in fermenting and curing the beans.

On some plantations kola nuts are grown among the cacao, producing a small yearly export of about 40 cwts. Among subsidiary products which do well wherever cacao and kola flourish, nutmegs occupy a prominent place.

Rubber

There are in British Guiana five indigenous species of *Sapium*, two of which yield rubber of marketable quality. The cultivation of neither of these species has, however, been successful, owing to the low yields obtained from the trees.

All the sapium rubber exported in previous years from the colony as "Orinoco scrap" was derived from the wild forest trees.

Since 1907 some interest has been shown in the cultivation of Para rubber, there being now about 4,050 acres under cultivation in the colony. The increase in area will be seen in the following table;

Year.	Area.	Increase.
	Acres.	*Acres.*
1907	410	—
1908	550	140
1909	1,000	450
1910	1,740	740
1911	2,260	520
1912	3,140	880
1913	4,000	860
1914	4,040	40

Companies formed for the cultivation of Para rubber hold the greater part of the land at present under cultivation, some 10,780 acres of Crown lands having been leased for this express purpose. The trees are young, and tapping on an extensive scale has not commenced. It is, however, anticipated that within a year tapping on an appreciable scale will be carried out by at least two of the companies at present engaged in the cultivation of Para rubber.

On suitable land the growth of the tree is not less rapid than it is in the East, while recent trials at the stations of the Department of Agriculture, and on some private properties, indicate that a yield of dry rubber per tree as good as that obtained on the best Eastern plantations is to be anticipated. The cost of collection of the rubber from a block of 400 trees at one station indicates that a reasonable profit can be expected with the market value of the product at 2*s*. per lb. The good health of the labour force, the low cost of supervision on estates, and the proximity of the colony to the United States of America, are factors which should encourage the extension of this industry in the colony.

Limes

Limes grow well on the lighter soils of the colony if they are protected from the full force of the wind. On the light, almost sandy soil of the Essequibo coast they grow excellently, as also on the laterite soils of the Essequibo river. In the interior of the colony lime trees flourish around the various settlements, where they bear large crops of excellent fruit.

There are very large areas of loose, friable land that are

well adapted to the cultivation of limes, whilst there is an enormous extent of ferruginous lateritic soils in many parts of the interior of the colony on which this crop can be successfully grown.

British Guiana should become one of the most important producers of limes and lime products in the world. The lime trees when well tended are generally free from diseases and insect pests, and the cultivations show signs of satisfactory progress.

The limes produced are juicy fruit, and their acid content is satisfactory. There is no difficulty in obtaining fruit for seed purposes, and attention is now being paid to seed-selection. Seedlings are readily raised, and after planting out need little attention if cultural and weeding operations are carefully carried out.

There are in the colony at present about 1,000 acres under limes; this area belongs mainly to two companies.

Cotton and other Fibres

The climate of the coastlands of British Guiana and the heavy nature of their available soil are not favourable for the successful growth of Sea Island or even of Egyptian cotton with commercial success. There are, however, several varieties of cotton in the colony which have been growing there for generations and which may now be regarded as practically indigenous. In the earlier years of the last century cotton obtained from these varieties formed a very important export from the colony. The cottons are perennial tree cottons and grow with great vigour, being apparently able to withstand the erratic meteorological conditions which sometimes prevail on the coastlands and which are detrimental to the yields of all varieties hitherto introduced. The lint is short-stapled compared with Sea Island, and is of about the same quality or somewhat better than rough Peruvian, worth 8*d.* to 9*d.* per lb. The price is not sufficient to induce the cultivation of the cotton on an extensive scale. It is probable, however, that an impetus would be given to the cultivation if agencies for the purchase

of the cotton in small quantities were established in the country districts.

Experiments in hybridisation have been in progress since 1908 by the Department of Agriculture, having in view the production of a heavily bearing perennial variety yielding lint of the Sea Island type, and there are indications that the objects of these experiments are being attained.

Among other fibres which offer promise for successful cultivation is the ginger lily, *Hedychium coronarium*. This is met with growing untended along the banks of some of the rivers on land containing fair quantities of organic matter, and a growth is there attained quite equal to that reported from Brazil. On the front lands of the colony, on the heavy soil, the plant does not make such good growth. Its experimental cultivation has been commenced by the Board of Agriculture both at the Botanic Gardens (coast) and at one of the agricultural stations situated on the bank of the Aruka river (North-Western District). In the former experimental cultivation the green weight of the stems and leaves obtained from a first crop six months after planting was equivalent to 22 tons of the raw material per acre, while a ratoon crop equivalent to 27 tons per acre was obtained six months later. A heavy third crop is now on the land. The stems and leaves as cut gave one-eighth of their weight in dry material suitable for baling for shipment. The results of the latter experiment, which is being carried out on a larger scale, are not yet available.

Cattle Raising

There are very large areas on the coastlands of the colony which are well adapted for the pastoral pursuits, especially for cattle-raising. At present there are about 90,000 head of cattle in the colony. About 600 head and a small number of hides—4,500—are exported annually.

Reference has been made to the very extensive savannahs of the far interior of the colony. Upon these great development may take place in cattle-ranching, for

which they are reported by all who have visited them as specially well adapted.

On the savannahs are scattered areas of well-watered fertile land on which the rancher can raise all kinds of tropical field and garden produce that he may require.

Future Extension of Agricultural Industries

Sugar

The sugar industry is by far the most important industry of the colony, and sugar, with its by-products rum, molasses, and molascuit, contributes almost 75 per cent. of the total value of the exports. About 33 per cent. of the wage-earning portion of the population are directly connected with the sugar industry, while if those indirectly connected are included the proportion is in excess of 50 per cent. of the population.

Of the empoldered area of the colony 44·7 per cent. is under sugar cultivation. About 85 per cent. of this is reaped each year. This indicates that in round figures 38 per cent. of the empoldered land contributes to the yearly production of sugar. The average production of sugar over the colony during normal years is about 1·8 tons of sugar per acre. On well-administered, suitably equipped, and satisfactorily financed plantations the average yield in fair years may be taken as 2·10 to 2·20 tons of sugar per acre per annum.

A conservative estimate of the area of land well suited for sugar cultivation, in the districts from the mouth of the Pomeroon in the north-west to the west bank of the Corentyne river in the east, is 531,000 acres, exclusive of the area already empoldered on sugar estates. Sixty-four thousand acres of this may be already beneficially occupied by products other than sugar, leaving nearly 470,000 acres available for the extension of sugar cultivation. At the present proportion of land yearly cropped with sugar to the total empoldered area, this would give in round figures 178,000 acres to be reaped each year, yielding a mean crop of 320,000 tons of sugar.

Given sufficient capital, labour, progressiveness, and enterprise, the colony's sugar crop on its eastern area could be increased to 570,000 tons of sugar per annum, which by fully applying modern scientific methods in cultivation and manufacture might be raised to 700,000 tons. Inclusive of the vast north-western section on the coastlands and along the lower reaches of the rivers of British Guiana, the total area of easily accessible land presumably well suited for sugar-cane cultivation, and at present not otherwise beneficially occupied, amounts in round figures to 1,620,000 acres. This area, if fully planted and reaped under modern conditions of cultivation and manufacture, could yield from $2\frac{1}{3}$ to $2\frac{1}{2}$ million tons of sugar per annum.

Para Rubber

Very large areas are available in the colony for rubber cultivation. The growth obtained by rubber trees has demonstrated that there are large tracts of land adjacent to the Demerara, Essequibo, Pomeroon, and Berbice rivers and in the North-Western District which are pre-eminently suited for the cultivation of Para rubber. It has been proved that the cost of collecting the product is reasonable. These facts indicate that extension of this industry in the colony should meet with much success.

Limes

There are wide areas of land available, and very suitable for the cultivation of citrus fruits. The growth attained by trees planted on the light lands of the lower reaches of the Essequibo river fully justifies an extensive cultivation of lime trees in the colony.

Coconuts

This product is suitable for cultivation over large areas in the lowlands of the colony. Local varieties of coconuts yield very heavy crops of medium-sized nuts on relatively heavy clay soils on the coastlands, whilst on lighter lands similar varieties produce much larger-sized nuts. There

can be no doubt that the colony is emphatically a coconut land, and that there are in it practically unlimited areas of land very suitable and readily available for coconut cultivation.

Rice

Great extension of the lands under cultivation with rice may be expected in the near future. There are hundreds of thousands of acres of land exceptionally well suited for its growth awaiting development.

Cacao, Coffee, Kola, Fruits, etc.

There are plenty of openings for the development of plantings of these products, the best of which, perhaps, are the lands bordering both banks of the Berbice river, along its course from about 30 to 150 miles from its mouth.

Forest Resources

These are practically illimitable; their utilisation, however, is checked by difficulties of transportation in the interior of British Guiana.

Balata

The trees from which balata is obtained are found growing all over the colony, particularly on the lower but not swampy lands along the banks of the smaller rivers and creeks. They are, perhaps, most abundant in the county of Berbice, where the balata-collecting industry has been established for the past fifty years.

The collection of balata is carried out under licences issued by Government. For the purpose of the administration of balata collection the colony is divided into sections of 50 or 250 square miles in area, the former in the more readily accessible and the latter in the less readily accessible parts of the colony. A separate licence is issued for each section, and confers the right to collect wild rubber as well as balata. The terms are for not more than fifteen years, an application fee of £1 13*s*. 4*d*. and an annual rental of £4 3*s*. 4*d*. for each licence, and a royalty

of 1*d*. per lb. on all balata and wild rubber collected. The licences are issued for collecting only, and may be cancelled if the land is required for agricultural or mining purposes. The collection is carried out by negroes and Aboriginal Indians, who are registered as bleeders. No tree is allowed to be bled which does not measure 36 in. in girth and 4 ft. from the base. Trees may be bled on one-half of the circumference only at any one time. No tree is allowed to be re-bled until five years have elapsed from the previous bleeding. The cuts employed for extracting the milk must be not more than 1½ in. wide and not closer together than 10 in.

The collectors proceed to the grants from January to April, and the work generally commences towards the end of May and extends to the beginning of October. The collectors are paid by the weight of balata obtained.

Bleeding is done by means of a cutlass; the incisions are 10 in. apart, and are arranged in a feather-stitch pattern. Bleeding is commenced at the base of the tree, and extends to the main fork; the branches of trees are seldom bled. The milk is collected in a calabash (made from the fruit of *Crescentia Cujete*), placed at the bottom of the tree, and held fast by inserting its lip between the bark and wood of the tree. The first bleeding is done while the collector is standing on the ground; the parts of the trunk situated higher up are bled by the aid of a ladder roughly constructed in the forest, while the highest parts are frequently reached by the aid of a rope for climbing.

The latex is transferred from the calabashes to kerosene tins and taken to the camp, where it is poured into a shallow tray (dabree) and allowed to evaporate. This tray is constructed generally of pieces split from the stem of a palm. The latex coagulates by evaporation, and the balata is removed in successive sheets from the top to the bottom.

The yield varies up to certain limits according to the age and size of the tree. Speaking generally, 5 lb. of dry balata per tree is considered a good yield.

Recent investigations have shown that the yields obtained by bleeding standing trees with cuts arranged in

the feather-stitch pattern are not less than those obtained by first felling the trees, and then extracting as much latex as possible by completely ringing the bark; and this fact has prevented the ruthless destruction of the tree, which is valuable for its timber as well as for its production of balata.

The following table shows the export of balata in five-year periods since 1893:

Period.	Total. *lb.*
1893–7	1,133,123
1898–1902	2,009,785
1903–7	2,488,951
1908–12	5,376,059

The exports go chiefly to the United Kingdom, the remainder going to the United States of America and to Holland.

The export of balata from the colony for the year 1913 was 1,323,609 lb., of the value of £160,000. Owing to the war closing some of the more important European markets the export for 1914 fell to 1,022,750 lb.

As the balata tree occurs in large quantity in the forests of the colony, and providing the product continues to realise its present market value, there is a prospect of the balata industry continuing to flourish for many years to come.

Rubber

From time to time small quantities of wild rubber are collected in the forests from the indigenous rubber-yielding species of *Sapium*. The rubber is of good quality. It is usually classed on the market as "Orinoco Scrap," and, if clean, fetches fair prices. The rubber of *S. Jenmani* has been examined at the Imperial Institute, and the results of its examination will be found in this BULLETIN (1909, **7**, 1). Small quantities of soft, inferior rubber also are yielded by indigenous varieties of *Hevea* (see "Rubber of *Hevea confusa* from British Guiana," this BULLETIN, 1912, **10**, 388), but there is very little chance of any development in the collection of rubber from indigenous trees taking place.

Timber

The fôrests of British Guiana cover some 78,000 square miles of country, or about six-sevenths of the whole area of the colony. The forests extend throughout the whole colony, but are broken at intervals by areas of savannah land. At present the workable area is confined to 11,000 square miles in the more readily accessible parts extending from the sea coast to where the courses of the large rivers, beyond their tidal reaches, are interrupted by cataracts, rapids, and falls. Timbers having a higher specific gravity than water cannot be transported by water-carriage over these obstacles. Therefore the utilisation of the practically illimitable forest resources of British Guiana is checked by great difficulties of transportation. There is little doubt that an enormous development of the timber industry would follow the institution of transport facilities by a railway to the interior of the colony.

The trees composing the forests of British Guiana are rarely of social habit. Many different kinds of trees exist in any one area, and the forests are of the class termed "mixed." The forests vary in height. On the low coast-lands and along the tidal reaches of the rivers the average height of the trees would be about 60–70 ft., but further inland they are more lofty and are on the average about 100 ft. in height. As a rule the trees in the high forests rise with straight, clean stems and are of small girth.

In parts of the forests it is usual for various kinds of trees to predominate and to form more or less broadly defined natural divisions of forest growth. These are known locally by the name of the prevailing kind of timber—as the greenheart, wallaba, and crabwood forests. Frequently the predominance of different kinds of timber is confined to situations defined by the nature and condition of the soil, and thus the natural divisions of forest growth are accentuated by different conditions of soil, and topographical features.

The following industries are carried on at present in connection with the forests of the colony:

Woodcutting for (*a*) Timber and lumber.
(*b*) Wallaba shingles, paling staves, and posts.
(*c*) Charcoal.
(*d*) Fuel.

Labourers for transportation or general work are engaged in these industries under contract for periods up to three months at a daily wage. For felling trees and squaring timber trained wood-cutters are required, and are paid at an agreed rate per cubic foot of the timber squared where felled. All hauling is done by gangs of men or by oxen, and the greater portion of the timber is floated down the rivers to convenient points for export.

The following are notes on the more important commercial timbers:

Greenheart.—This is commercially the best known of all the timbers of the colony. Large quantities have been regularly exported for many years. It is rated as a first-class wood at Lloyd's, and it is chiefly used for submerged works such as wharves, piles, dock and lock gates.

The brown or yellow greenheart is hard, heavy, tough, strong, and elastic, and is said to have the property of resisting the Teredo. The black variety is much scarcer. It can be distinguished from the brown variety by its colour and greater hardness. Logs of greenheart can be obtained from 10 to 25 in. square, and up to 65 ft. in length.

In habit the greenheart is partly gregarious. It favours hilly land with a sandy clay soil, and is usually found more abundantly on the slopes of the hills. The greenheart areas are estimated to contain an average of thirty-two greenheart trees to the acre, and are almost entirely confined to the central parts of the colony, which are traversed by the Essequibo, Demerara, and Berbice rivers and their tributaries. There is a large quantity of this wood in the interior regions waiting easier means of transport for exploitation. For the results of examination of this wood and of several others mentioned in this article see *Technical Reports and Scientific Papers of the Imperial Institute*, 1903, Part i. p. 281.

Crabwood.—There are two varieties of West Indian mahogany (*Carapa guyanensis*), locally termed crabwood, the red and the white. The former is a red coloured wood, with a moderately coarse and open grain. It is largely used in the colony for building purposes and is the most popular furniture wood. It resembles mahogany in appearance when polished, and has proved itself to be a good substitute for that wood. The white is similar in structure to the red variety, but paler in colour and of less specific gravity. Logs of this wood can be obtained from 40 to 60 ft. long, and from 10 to 16 in. square.

The tree is found growing scattered throughout the forests of the river valleys of the colony, particularly on low-lying flat lands subject to inundation either by high tides or heavy rains. It also occurs in lesser quantities in the more elevated country.

Wallaba.—There are several varieties of this wood; those principally used are "soft wallaba" (*Eperua falcata*) and "Ituri wallaba" (*Eperua Jenmani*). The heart-wood of these varieties is in great demand for posts and for making shingles, palings, vat staves, etc. Wallaba is a heavy, hard wood, with a very coarse but more or less even grain. It splits readily, is very resinous, and has an unpleasant smell which, however, disappears after a sufficiently long exposure. It is probably the most abundant of the colony's timbers.

On the slightly elevated and hilly lands of loose white sand situated in the central and eastern parts of the colony the wallabas constitute about 40 per cent. of the forest trees. In the forests of the swamp lands the two kinds above mentioned, together with "Bimiti wallaba," which is only used for fuel, are found on places where the soil is more or less of a sandy nature.

Other Woods.—In addition to the above-mentioned woods there are many other valuable timbers, of which, at times, some are exported in small quantity.

The following hard woods may be mentioned: Mora (*Dimorphandra Mora*), rated first-class at Lloyd's, and used for railway sleepers. It grows near to the banks of the rivers and creeks, is of large size, and is useful for many

purposes. Bullet tree (*Mimusops globosa*) is now cut only by permission for special purposes, it being the source of balata. The wood is dark red, close-grained, heavy, and durable. Suradanni (*Hieronima alchorneoides*) grows in low situations and is fairly plentiful. The wood is of a deep red colour. Purple-heart (*Copaifera publiflora*) is one of the tallest trees of the forests. The wood is of a dark purple colour and is hard, close-grained, and durable. Locust or simiri (*Hymenoea Courbaril*) grows in sandy soils. The wood is hard, heavy, and close-grained, and takes a fine polish. Other hard woods of local commercial value are hackia (*Siderodendron triflorum*), towaronero (*Humiria balsamifera*), kakaralli (*Lecythis corrugata*), Tonkin bean or kumara (*Dipteryx odorata*), hiawaballi (*Omphalobium Lambertii*), kabukalli (*Goupia glabra*), and phokadie (not identified).

Of soft woods mention may be made of silverballi or siruaballi (*Nectandra* spp.), of which there are several varieties, the yellow, brown, keritee, yekuru, and mainap, all handsomely grained woods with an aromatic scent. They are durable woods and are used principally for planking boats and for making knaves of wheels. Determa (*Nectandra* sp.) is well adapted for making corials and canoes, and for masts and spars of vessels. It is a light, strong wood, resembling cedar in colour. Soft woods of local commercial value are hoobooballi (*Mimosa guianensis*), arrisouroo (*Pterocarpus guianensis*), white cedar (*Tabebuia longipes*), and red cedar (*Protium altissimum*).

The very soft woods include simarupa (*Simaruba officinalis*), which grows throughout the colony, especially on sandy soils. The wood is of light colour and is close-grained. It is useful for inside house-work. Dalli (*Myristica surinamensis*) and phootee (*Jacaranda Copaia*) occur in fair quantities and are used for lumber, making matchboxes, etc.

Charcoal Burning.—This industry is principally carried on where the lands are of a sandy nature on the Demerara and Berbice rivers. The wood is converted into charcoal by burning it in covered pits dug in the sand, in which the wood is packed with the coarser material in the middle.

All kinds of wood, and all parts of the trees are used. The charcoal is largely exported to the Southern West Indian Islands.

Firewood.—On the sea coasts, courida (*Avicennia nitida*) is much used as a firewood. On the river lands all kinds of woods are cut for fuel, but wallaba is mostly favoured, as it splits readily and burns well. Practically all the firewood exported is obtained from the lower Demerara river, whence it can be transported cheaply for shipping to Barbados and other West Indian Islands.

Exports of Timber Products

The colony annually exports about 250,000 cubic ft. of timber, 80,000 bags of charcoal, 8,500 tons of firewood, 250,000 ft. of lumber, and 2,500,000 wallaba shingles. These exports have a total average value of £37,000 a year.

Gums, Oils, Resins, etc.

Small quantities of gums are collected and exported. Gum animi, a product of the locust tree (*Hymenoea Courbaril*) is exported in small quantities. At one time there was a good demand for this product, but not much has been exported of late. The fossil gum resembles amber in appearance and is often found in blocks of considerable size.

Hiawa gum or "resin of conima," used for incense, is obtained from *Protium heptaphyllum*, a tree common in all localities of the colony, and can be had in considerable quantities.

Tonkin beans are collected and exported. They are yielded by the kumara or Tonkin bean tree, a large tree growing plentifully in localities above the rapids and in the upper islands of the Essequibo river and its tributaries.

Souari nuts (or butter nuts), the product of *Caryocar tomentosum*, are also collected. The souari nut tree is one of the giants of the forest and thrives best on hilly lands of a clayey nature. Trees under cultivation at Onderneeming Experiment Station have fruited in six years from planting.

The seeds of the Carapa, or crabwood, are collected, and

from them the well-known "crab-oil" is obtained. The greater proportion of this oil offered for sale is manufactured by the Indians.

It is very evident from the foregoing that British Guiana is a land of vast potentialities only limited by lack of transport facilities, labour, and capital. It is reasonable to expect that provision of quick and cheap means of transport, such as would be supplied by railways traversing in various directions the interior of the colony, would be quickly followed by an influx of labour and of capital, by which the great resources of the colony would be rapidly developed.

GENERAL ARTICLES

THE ECONOMIC RESOURCES OF THE GERMAN COLONIES

II. German South-West Africa

(With a Map)

The present article is the third of a series of articles dealing with the economic resources of the German colonies, the first dealing with the mineral resources and the second with the agricultural and forest resources of German East Africa (this Bulletin, 1914, **12**, 580; 1915, **13**, 110).

German South-West Africa was the only German colony suitable for colonisation by Europeans. Unlike German East Africa, the cultivation of crops has up to the present been of little importance, the chief activities being devoted to animal and mineral production.

German South-West Africa, now occupied by the troops of the Union of South Africa, has an area of about 322,450 square miles, that is over 45,000 square miles larger than the Cape of Good Hope Province. It is bounded on the north by the Portuguese territory of Angola, on the east by Rhodesia and Bechuanaland, on the south by the Cape Province, and on the west by the Atlantic Ocean, except

for the small British territory of Walfish Bay, situated about halfway along the coast. A narrow strip of territory running eastwards from the north-east corner of the Protectorate as far as the Zambesi is known as the Caprivi enclave. The northern, central, and southern portions of the country are known respectively as Ovampoland, Damaraland, and Great Namaqualand, names derived from the dominant native race in each region. The coastal region in the northern third of the Protectorate is sometimes known as Kaokoland.

The coast line extends for about 800 miles from the mouth of the Kunene river in the north to that of the Orange river in the south; it is but little indented, and has no good natural harbours. The land bordering the coast is low and sandy (see p. 238), but the coastal belt is flanked by a mountain range, the highest point of which (Mount Omatako, north-east of Omaruru) reaches an altitude of over 8,700 ft. North-east of Omatako is the Omboroko or Waterberg range. In the south-east are the Great Karas mountains, the highest point of which is over 7,200 ft., and just west of these are the Little Karas mountains, which reach a maximum altitude of over 4,800 ft. In the northern part of the country the central plateau contains much rich grass land and constitutes the main grazing ground. The extreme north-east region is occupied by the Omaheke desert and in the eastern part of the Protectorate stretches the arid Kalahari desert.

The chief rivers flowing into the Atlantic are the Kunene, which for part of its course forms the northern boundary of the Protectorate, and the Orange river, forming the southern boundary. Neither of these is navigable, although they carry water all the year round. The Great Fish river, nearly 500 miles long, flows into the Orange river and is rarely dry. Part of the north-east boundary is formed by the Okavango, a perennial river which flows into Lake Ngami in Bechuanaland. The other rivers of the country are dry for a varying part of the year.

The chief ports are Swakopmund, at the north of

SKETCH MAP OF
GERMAN SOUTH WEST AFRICA.

Ordnance Survey Office, Southampton, 1914.

Walfish Bay, and Lüderitzbucht (Lüderitz Bay) further south. The capital, Windhuk, is situated in the centre of the Protectorate, at an altitude of over 5,500 ft. Other important inland towns and settlements are Okahandja, Karibib, and Omaruru, north and north-west of Windhuk, Waterburg further north, and Otavi (Otawi) and Grootfontein in the north-east. South of Windhuk are Rehoboth, Maltahöhe, Gibeon, Bethanien, and Keetmanshoop. In the extreme south-east, near the Orange river, is Warmbad.

For administrative purposes the Protectorate, exclusive of Ovampoland and the Caprivi enclave, is divided into sixteen districts: Grootfontein and Outjo in the north, Gobabis, Gibeon, and Hasuur in the east, Warmbad in the south, and Lüderitzbucht and Swakopmund in the west; in the centre, from north to south, are Omaruru, Karibib, Okahandja, Windhuk, Rehoboth, Maltahöhe, Keetmanshoop, and Bethanien. The total white population in these districts on January 1, 1913, amounted to 14,830, of whom 12,292 were Germans and 1,799 British subjects, most of the latter being Boers settled in the south-eastern districts. The native population on the same date was estimated at 78,810. In addition there are anything between 150,000 and 200,000 natives in Ovampoland and the Caprivi enclave, and 2,648 natives from abroad resident in the country, mainly from the Cape.

As regards internal communications there is a good service of railways. One, managed by the State, runs from Swakopmund through Karibib, Okahandja, and Windhuk to Mariental; another from Swakopmund through Omaruru to Grootfontein, with a short branch line to Khan, and another from near Otavi to Tsumeb, was managed by the Otavi Mining and Railway Company; a third from Lüderitzbucht through Keetmanshoop to Mariental, with a southern branch line to the diamond fields on the coast, and another from Seeheim to Kalkfontein, was also controlled by a private company. In all about 547 miles of narrow gauge and 771 miles of Cape gauge were open to traffic in 1913. In addition, good roads have been constructed between most of the important towns and settlements.

There were seventy postal stations in the Protectorate

on March 31, 1914, fifty of which were connected with the telegraph system, whilst twenty-eight towns and villages were connected by telephone. A powerful wireless station was erected at Windhuk which could communicate with Berlin *via* the station in the Cameroons, and another at Lüderitzbucht which was destroyed by the Germans during the recent military operations in the Protectorate.

A considerable drawback to the economic development of the country is the lack of surface water in many parts, but wells have been sunk along most of the roads and these provide a fairly good supply. Artesian wells exist at various places in the valley of the Auob river in the Kalahari desert, and at Keetmanshoop. An ample water supply has been made available by boring at Windhuk, whilst works were commenced for the supply of water to Lüderitzbucht by borings in the valley of the Kuichab river near Aus.

Climate

There are two usually well-marked seasons in German South-West Africa: a cold dry season which lasts from May to September, and a hot season from October to April. The rainfall is lowest in the south, the mean annual rainfall in places on a south to north line, according to Knox (*The Climate of the Continent of Africa*, Cambridge, 1911, p. 491), is as follows: Warmbad 4·25 in., Keetmanshoop 6·38 in., Hoakhanas 7·87 in., Windhuk 15·04 in., Waterburg 20·51 in., and Grootfontein 23·39. The rainfall increases from west to east, Lüderitzbucht and Swakopmund on the coast having a mean annual rainfall of only 0·79 in. and 0·83 in. respectively, whilst at Gobabis, near the eastern frontier, at about the same latitude as Swakopmund, the rainfall is 16·46 in. The rains, however, are irregular, some years being very dry, others more moist. Thus 1910 and 1912 were dry years, separated by a period of good precipitation in 1911, when the time of chief rainfall, properly belonging to the next year, set in as early as the end of October. Even in this year, however, when the precipitation of the previous eleven years was mostly exceeded, the rainfall in the south was unsatisfactory.

A characteristic feature of the climate is the prevalence of night fogs in the Namieb, an extremely arid tableland east of the coastal sand dunes. Pearson (*Kew Bulletin*, 1907, p. 349) states that in January the mist was so heavy that water was dripping from the branches of the bushes, and the ground was discoloured by the moisture.

The temperature is lowest from May to the end of October, when the continental climate brings night frosts in many places, causing damage to garden and orchard crops. Similar destruction is also brought about by hail, which sometimes accompanies thunderstorms. The mean annual temperature at Swakopmund is 59·5° F., the mean daily range being 14·4°; the highest temperature recorded during a period of seven years was 105·1° and the lowest 36·5°. At Windhuk the mean annual temperature is 66·5° F. and the mean daily range 25·3°, the highest temperature recorded for four years being 98° and the lowest 26·5°.

Earthquakes are fairly frequent along a recognised line running in a south-westerly direction from Otjimbingwe to Kaltenhausen. They also occur from time to time in other places, especially along the so-called Windhuk well fissure, connected with the line just mentioned. The shocks are not very serious in nature, though they may be sufficiently severe to do slight damage to buildings.

Mineral Resources

Salient Geological Features

With regard to its physical features, German South-West Africa may be divided roughly into three tracts, viz. (1) a narrow and sandy coastal strip; (2) a mountainous interior; and (3) the broad expanse of the western Kalahari desert.

(1) The low-lying sandy belt along the coast is of varying width; it is insignificant in the north on the Kaokoland coast, but to the south of the river Kuiseb, which flows into Walfish Bay, it stretches inland for about 62 miles; and in the district north of Lüderitzbucht, where it extends as far as the Tiras plain, it attains a width of some 80 miles. This broad strip on the Great Namaqua-

land coast is largely covered by sand dunes, though the sandy tract is pierced in places by isolated mountain masses built of the older rocks.

The sand dunes are very abundant and difficult to traverse in the region between Swakopmund and Lüderitzbucht, and some of them are of large size, reaching a height of about 650 ft. Near the coast the dunes are bare, and wander about under the influence of the strong south-west winds; but further inland they have a scanty covering of vegetation, and to the south of Pomona they are covered with grass and bush.

In various parts of the coastal tract there occurs a rock which consists of sand and gravel cemented by calcium carbonate. This rock is diamantiferous, and appears to be a recent lime-pan deposit. On some parts of the Great Namaqualand coast, however, there are fossiliferous strata to which Cretaceous and Tertiary ages have been assigned.

From an economic standpoint the coastal tract of Namaqualand is of great importance owing to the fact that the sand is diamantiferous (see p. 242). Another economic feature of note in connection with the coastal tract is the occurrence of guano deposits. These have been worked at Hottentot Bay just south of latitude 26°, and they probably occur at other parts of the coast.

(2) The mountainous area of the interior is made up almost entirely of rocks, the youngest of which are, from a geological standpoint, comparatively old. Three distinct formations have been made out in the various districts, viz.:—

A. The pre-Cambrian or Archæan group.

B. The Namaqualand and Otavi formations of the south and north respectively.

C. The Karoo and Kaoko formations of the south and north respectively.

A.—The pre-Cambrian or Archæan group of rocks comprises gneisses, schists, amphibolites, crystalline limestones, and intrusive granites, and corresponds to the basement complex of other parts of Africa. Outcrops of these pre-Cambrian rocks are found over wide areas in Great Namaqualand and Damaraland. In Namaqualand they

strike roughly north and south, whilst in mid-Damaraland the predominant strike is north-east and south-west. Notable heights in these pre-Cambrian areas are the Great Karas mountains of Namaqualand, which rise to a height of about 6,500 ft., and Mount Omatako in Damaraland, which attains a height of nearly 9,000 ft.

Among the pre-Cambrian gneisses, schists, and the granites intrusive in them, there occur highly mineralised pegmatites containing tin ore, wolframite, copper ores, molybdenite, and other useful mineral deposits.

B.—Resting unconformably on the pre-Cambrian rocks is a series of sediments consisting of shales, sandstones, dolomites, quartzites, and a basal conglomerate. These are known by the name of the Namaqualand formation in the south of the Protectorate, and the Otavi formation in the north. These two formations are probably the same; they are presumably of early Palæozoic age, and in the main are considered as the equivalents of the Transvaal System, including the Black Reef, Dolomite, and Pretoria series. The Otavi formation is economically important chiefly on account of the occurrence in it of important copper-ore deposits.

C.—Lying unconformably on the Namaqualand series in Namaqualand, notably in the neighbourhood of the Fish river, and especially to the north of Gibeon, are the Karoo beds, with a glacial conglomerate at the base (Dwyka conglomerate). The younger Karoo beds consist of shales, marls, and sandstones; they attain a thickness of nearly 1,000 ft., and plant remains are frequently found in them. It is possible that coal beds may occur in them, but with the exception of small seams of poor quality that are stated to have been observed during boring operations at Anros, near Keetmanshoop, no coal occurrences have hitherto been reported.

In the Karoo strata, as elsewhere in the Karoo series in South Africa, there are extensive dykes and sills of dolerite, which exhibit the spheroidal type of weathering so typical of dolerites. In addition to the dolerite intrusions there occur pipe-like intrusions of peridotite. These pipes resemble in form the diamantiferous kimberlite pipes at

Kimberley and elsewhere. They occur in the district between Gibeon and Berseba, and also on the Lion river, an eastern tributary of the Fish river (shown on the map immediately south of Seeheim), but hitherto no diamonds have been found in the pipes of German South-West Africa.

In the northern portion of the Protectorate, the Otavi series is succeeded unconformably by a sequence of sandstones and shales that has been described under the name of the Kaoko series. These are the possible equivalents of the Namaqualand Karoo series, but their age has not been definitely established. No glacial conglomerate has yet been found at the base of this series, though an ordinary quartz conglomerate occurs; and no coal beds have been observed in this series.

Basalts and dolerites overlie the sandstones of the Kaoko series in Kaokoland and cover a large area in the west and south-west of the Kaokoland region, where they reach the coast and cap extensive tablelands.

Throughout the hilly interior of the Protectorate the older Palæozoic and Karoo strata are in the main approximately horizontal, and form extensive plateaux which are in places very much dissected, so that large tracts of the older pre-Cambrian rocks formerly covered by these younger beds are now exposed. Occasionally the Namaqualand and Karoo beds are folded or highly inclined and provide a departure from the plateau type, but for the most part they show only a very slight easterly dip and the surface slopes gradually eastwards until these older rocks become buried under the superficial deposits of the Kalahari desert.

The Ovampoland region in the extreme north of the Protectorate and a large area to the east of Kaokoland and north of the Otavi district is very flat, and covered by recent deposits of the Kalahari type.

(3) The Kalahari desert is covered by recent surface deposits. These consist of sands, loams, marls, and limestones. In the southern Kalahari there are extensive sand dunes. Underlying the sand in some localities, as to the east of the Great Karas mountains, and forming the bare

surface in many places, is a deposit of limestone known as the Kalahari limestone.

Opinions seem to differ as to the age of these surface limestones. Fossils are absent from many of them, and in others the evidence provided by shell remains appears to be inconclusive. There can, however, be no doubt that limestones, arising by cementation of recent surface deposits, are widespread in the Kalahari region. Surface limestones occurring in the form of travertine are found in many parts of the Protectorate, and are used to a small extent as a source of lime.

Chief Economic Mineral Deposits

The chief economic minerals of German South-West Africa are the diamonds of the south-western coastal district in the vicinity of Lüderitzbucht, and the copper and lead ores of the Otavi district.

Diamonds.—The diamonds of German South-West Africa occur in the sandy coastal tract north and south of Lüderitzbucht. They have been proved to occur over a somewhat broken belt stretching from the vicinity of Conception Bay (Lat. 24°) to the vicinity of Chamis Bay (Lat. 28°), along a distance of nearly 300 miles. The most productive area hitherto has been that in the vicinity of Lüderitzbucht and the district to the south as far as Pomona Island.

The diamonds occur in a superficial layer of gravelly sand, in which they are associated with coarse grains and small pebbles of quartz, felspar, chalcedony (including agate and jasper), garnet, epidote, magnetite, and hæmatite. In certain areas, as at Pomona, the diamonds have been concentrated by wind action, and have been left behind in a surface residue of rich gravel. The diamond-bearing gravel varies in thickness from a few inches up to a few yards, and the distribution of the gemstone in the gravel is very irregular, barren areas of gravel lying adjacent to areas in which there is an abundance of diamonds.

At most localities the stones are small and of fairly uniform size, four or five being required as a rule to make

up the weight of one carat. They generally show good crystalline form, with the rhombic dodecahedron and octahedron as the predominant forms. As a rule the diamonds occurring to the south of Lüderitzbucht are larger than those occurring to the north. Stones exceeding 3½ carats in weight do not occur in the northern area, whereas they are not infrequent in the area to the south. The largest diamonds occur in the area beween Pomona and Bogenfels. At Bogenfels a stone having a weight of 17¼ carats has been found, whilst at Pomona, where the diamonds reach their greatest average size, a stone having a weight of over 34 carats has been found; this is the largest stone recorded from German South-West Africa.

The degree of concentration of the diamonds is very variable. At Pomona, gravel containing 60 carats to the cubic metre has been worked. Elsewhere the gravel contains a much smaller proportion of the gemstone, and at Kolmanskop the average yield during 1912 was only about two-fifths of a carat per cubic metre.

The colour of the diamonds is variable, but the majority of the stones are colourless or nearly so. Yellowish, pinkish, bluish, and greenish stones also occur. The quality of the stones is uniformly high, and 85 per cent. of the output consists of stones suitable for cutting as gemstones. The bort variety of diamond appears to be absent from the deposits or present only in very small amounts.

Opinions seem to differ as to the comparison of the diamonds of German South-West Africa with those of the Union of South Africa. According to some authorities they resemble the Kimberley type. Some experts on South African diamonds, however, are of opinion that they differ greatly from the pipe and alluvial types occurring in the British portion of South Africa, and these hold the view that the stones more closely resemble those of Brazil.

The origin of the diamonds in the coastal sands is a matter of controversy. According to some they are supposed to have been derived from pipes of kimberlite similar to those found elsewhere in South Africa. Such

pipes occur in German South-West Africa, as for example at Gibeon and Berseba, but hitherto no diamonds have been found in the pipe rocks.

Amygdaloidal dolerites containing agates occur abundantly on the coast, and the fact that agates occur in association with the diamonds has led some to believe that the dolerites are probably the source of the diamonds.

From the occurrence of a diamond-bearing cemented gravel of supposed Cretaceous age at various parts of the coast it has been inferred that the diamond was deposited in this gravel during Cretaceous times from a source now buried beneath the sea, and that the loose diamonds now found in the shore deposits have resulted from the disintegration of this Cretaceous rock. Proof that this rock is of Cretaceous age appears to be lacking, however, and the rock in question is more probably a cemented diamond-bearing gravel of recent age.

Still less worthy of attention are the hypotheses that the diamond has resulted from the disintegration of the pre-Cambrian gneisses, or that they have been carried to the coast by the Orange river. Much remains to be done before it can be definitely ascertained exactly how the diamonds have originated. The fact that the most concentrated gravel occurs in the Pomona district, the fact that this is the district where the largest stones occur, and the further fact that the diamonds tail off and diminish in size as they are traced northwards from this locality, all point to the view that the mother rock of the diamond probably exists somewhere in the vicinity of Pomona. Assuming this to be the centre from which the stones have been drifted along the coast, the nature of the prevailing winds and shore currents would explain the existing distribution of the diamonds in the coastal sands very well. Much interest therefore attaches to the further work that may be done in investigating the bed rocks of the Pomona and Bogenfels districts; and considering the fact that the presence of basic intrusions on the coast has already been established, it would not be surprising if there should be found in these districts some diamond-bearing basic dykes

or pipes of the peridotite type from which the diamonds may have been derived, though there is a possibility that the parent rock may be submerged somewhere off the coast.

It was not until the year 1908 that diamonds were discovered in German South-West Africa. The output in that and succeeding years is given in the following table:

Year.	Quantity. *Carats.*	Value. £
1908 . . .	39,375	2,559
1909 . . .	483,268	771,776
1910 . . .	867,296	1,343,004
1911 . . .	747,152	1,151,707
1912 . . .	992,380	1,520,704
1913 . . .	1,570,000	—

Of the output during 1913, 1,284,727 carats were sold for £2,153,230, the average value being £1 13*s.* 6*d.* per carat, whereas during 1912, 902,157 carats were sold for £1,303,092, the average value being £1 8*s.* 8*d.* per carat. This increase in value per carat was due to the large output at Pomona, where the largest stones occur. The stones produced by many of the companies ran 8 or 10 stones to the carat during 1913, whereas those obtained at Pomona averaged rather less than 3 stones to the carat; and, as already mentioned, it was in the Pomona area that a stone weighing over 34 carats, the largest hitherto found in German South-West Africa, was obtained.

All the diamonds have hitherto been exported to Germany in the first instance.

Copper Ore.—The chief copper ore deposits of the Protectorate are those of the Otavi district, the most important mine being that at Tsumeb. Other occurrences of note include the Otjisongati mine, north-east of Windhuk, the Khan copper mine, the Ida mine near Husab, both in the Swakopmund district, and the Sinclair mine in the north-east of the Lüderitzbucht district.

At Tsumeb, in the Otavi district, the ore-body occurs in the grey compact dolomite of the Otavi series. The ore-body at and near the outcrop has the form of steeply-dipping lenticular veins. The predominant rock of the district is dolomite, but the hanging wall of the vein con-

sists of a bed of sandstone, and the foot wall is of dolomite with some clayey impurity. Near the surface there were two large lenses of rich ore separated by an intervening mass of rock poorer in ore minerals. The ore is brecciated, and contains inclusions of the neighbouring sandstone and dolomite.

The chief ore minerals are galena, chalcocite, enargite, famatinite, and zinc blende. Associated with these is a little pyrite; quartz and calcite also occur in the ore. A notable feature of the Tsumeb ore-body is the large variety of minerals arising from oxidation at and near the surface. These include anglesite, cerussite, smithsonite, hemimorphite, hydrozincite, linarite, aurichalcite, caledonite, cuprite, native copper, malachite, azurite, brochantite, barthite, otavite, greenockite, bayldonite, chenevixite, olivenite, tsumebite, mottramite, vanadinite, and wulfenite.

In the easterly lens of ore at Tsumeb, galena was the predominant ore mineral; the ore in this lens showed an average percentage composition as follows: lead, 50; copper, 10; antimony, 0·5 to 2; arsenic, 1 to 2; silver, 0·02; gold, a trace.

The westerly lens showed a larger percentage of copper, and gave the following average percentage composition: lead, 20 to 30; copper, 15 to 25; antimony, 0·5; arsenic, 1 to 2; silver, 0·02 to 0·03; gold, a trace.

As regards the origin of the ore body, it seems highly probable that the main sulphidic portion has been deposited from ascending solutions along a zone of fracture, and the prospects at deeper levels are good.

Elsewhere in the Otavi district, chiefly in the Otavi valley, copper ore is being worked in the dolomite at various localities under conditions of occurrence closely resembling those at Tsumeb.

There are numerous other deposits of copper ore in various parts of the Protectorate, but these are chiefly among the pre-Cambrian rocks, and are of a different type from those found in the Otavi district.

Perhaps the most important of these is the deposit at Otjisongati, where lenticular veins of quartz traverse pre-Cambrian gneisses. The predominant ore-mineral in

the quartz veins is chalcocite, but at the outcrop there is an abundance of oxidised copper ore containing the minerals malachite, azurite, cuprite, chrysocolla, and native copper, associated with limonite.

At the Sinclair mine quartz veins traverse gneiss and schist, and the occurrence closely resembles that at Otjisongati. Somewhat similar mineralised quartz veins are found in granite at Neuras and other localities to the south-west of Rehoboth, and at Spitzkopf to the north-west of Rehoboth.

At Gaidip, on the Orange river, east of Ramansdrift, copper ore occurs in a steeply dipping vein about 2 metres thick, in the neighbourhood of an intrusion of quartz-diorite. The predominant vein mineral is quartz. The ore minerals are chalcopyrite and bornite, associated with pyrite. Malachite and limonite are abundant at and near the surface.

The copper-ore deposits of the Khan valley in the Swakopmund district closely resemble those at Gaidip. In recent developments at the Khan copper mine, the mine has been opened up along a length of 1,300 ft. and to a depth of about 750 ft. The vein is 6½ ft. thick, and carries about 7½ per cent. of copper. This mine, as was mentioned earlier in this article, is connected with the Otavi railway. A concentration plant was recently installed, and was expected to be in working order during 1914. The Ida mine near Husab has also been developed recently.

In various parts of Damaraland, copper-ore deposits occur as impregnations of mica schist. At the Gorap mine a schist impregnation of this type is found. The schist is associated with amphibolite and quartzite. The ore minerals are cuprite and limonite, with streaks of malachite and azurite. Volborthite, a greenish-yellow vanadate of copper, is also present in this ore.

Another deposit in which copper ore is found as an impregnation of mica schist is that at the Matchless mine to the south-west of Windhuk. Here again the mica schist is associated with amphibolite and quartzite. The ore minerals are cupriferous and arsenical pyrites associ-

ated with chalcocite, and oxidised to malachite and limonite at the surface.

Impregnation deposits of this type in schist occur at various other localities among the pre-Cambrian rocks. They are of little importance in comparison with the deposits among the dolomites of the Otavi district, but a large amount of energy has been displayed in prospecting and developing them.

The output of copper ore by the Otavi mines for the year ending March 31, 1913, was 54,100 tons. Of this total 44,500 tons was shipped, and this contained on the average 13 per cent. of copper, 25 per cent. of lead, and 230 grams of silver per ton. During the same period the Otavi company shipped 665 tons of copper matte containing 48 per cent. of copper, 25 of lead, and 440 grams of silver per ton; as well as 400 tons of crude lead containing 98 per cent. of lead and 910 grams of silver per ton.

An increase in the rate of output took place during the six months ending September 30, 1913, during which 25,560 tons of copper ore, 507 tons of copper matte, and 45 tons of crude lead were shipped.

Nearly the whole of this output is from the Tsumeb mine. The Otavi valley mines contribute some 2,000 tons of ore. The output at Otjisongati and other localities is comparatively insignificant.

Other Economic Minerals

Less important at present than the diamond and copper-ore deposits that have been already described, but perhaps important from the standpoint of prospective development are the occurrences of auriferous copper ore, argentiferous galena, cassiterite (tin ore), wolframite (tungsten ore), molybdenite (molybdenum ore), mottramite (vanadium ore), iron ores, tantalite, monazite, and beryl that are found in various parts of the Protectorate. Marble of good quality also occurs, and has been quarried to some extent for export to Germany.

These less important economic minerals are here dealt with in alphabetical order.

Asbestos.—Asbestos of the tremolite variety, but apparently of little or no economic value, is found at several localities. The chrysotile variety of asbestos is reported to occur near Kolmanskop near Lüderitzbucht.

Beryl.—The mineral beryl, for the ordinary variety of which there is a small demand in connection with the manufacture of mantles for incandescent gas-lighting, occurs in various parts of German South-West Africa, and is found in association with tantalite in the pegmatite veins of Tonkerhoek (Donkerhuk).

A clear golden yellow variety of beryl, known in the gem trade as "heliodor," occurs in pegmatites near Rössing, on the Otavi railway some 25 miles to the east of Swakopmund. Ordinary beryl also is found in these Rössing pegmatites, associated with tourmaline and wolframite.

Beryl is also recorded from the lower course of the Fish river, between Aiais and Gaibes.

Gold.—There has been much prospecting for gold in German South-West Africa, but hitherto no deposits of importance have been found. Nuggets of gold are reported to have been found in the alluvial tinstone deposits at Neineis in the Erongo mountains, to the north of Karibib. At Spitzkopf, to the north-west of Rehoboth, copper ore, containing 62 per cent. of copper and 11 pennyweights of gold per ton, is reported to occur; but the amount of ore available appears to be very small. Gold is also found at Swartmodder, in the Rehoboth district; and quartz veins carrying gold and silver have been observed at Kunjas, some 70 miles north-east of Aus, in the Bethanien district. Copper-lead ore in quartz veins traversing granite in the area south-east of Little Karas mountains, south of Keetmanshoop, is stated to be auriferous.

Iron Ore.—Iron ores occur abundantly among the pre-Cambrian rocks, and in the Otavi series.

There are important deposits some miles to the north-west of Kalkfeld (Okowakuatjiwi) on the Otavi railway, forming a hill mass about 50 metres high, 300 metres long, and 100 metres broad. The ore-body consists of calcareous brown iron oxide. It is found at the contact of a gabbro-like mass that is intrusive in crystalline limestone.

This ironstone, an average sample of which contained 60 per cent. of ferric oxide, has not yet been used as an iron ore; but it has been used as a flux in the smelting of the Otavi lead-copper ores.

Lead Ore.—Galena is one of the chief constituents of the Otavi copper-lead ores (see copper ore, p. 246). Argentiferous galena was formerly worked to some extent in the Pomona district. Auriferous lead-copper ore is reported to occur in quartz veins traversing granite in the area to the south-east of the Little Karas mountains. Promising deposits of galena are stated to have been developed at Aiais, on the Fish river.

Marble.—Crystalline dolomitic limestones are found among the metamorphosed pre-Cambrian rocks. Among these, good white marble of fine grain and suitable for statuary purposes occurs, as for instance at Etusis and other localities in the Karibib district; but as usual in crystalline magnesian limestones, there is apt to be an abundance of secondary silicates, especially tremolite, which renders blocks containing them unfit for carving purposes. A red variety of marble is also found. Deposits of marble are reported to occur on the coast near Easter Cliffs in the north of the Lüderitzbucht district, but these are at present beyond the reach of transport facilities.

Marble has been quarried for several years at various localities near Karibib. The amount exported from the Karibib district during 1912 was about 250 tons, valued at about £1,000, compared with 14½ tons valued at about £62 in 1911. Marble quarrying has recently been pushed forward with much energy, in the hope of establishing a greater demand for the material in Germany.

Molybdenum Ore.—The mineral molybdenite is found frequently in the form of disseminated flakes among the granites and older rocks, and also in the pegmatites associated with granitic intrusions. In some localities, as at Otjisongati, and in the district south-east of Warmbad, it occurs in its familiar association with chalcopyrite and pyrite. At Gansberg near Hornkranz in the western part of the Rehoboth district it occurs in a pegmatite associated

with tourmaline and limonite. At Ubib, in the north-east of the Swakopmund district, molybdenite is found disseminated in red granite, and also in the form of lenticular aggregates in schists into which the granite is intrusive. At Tsumeb, in the Otavi district, wulfenite, an ore mineral of molybdenum, is found among the oxidised copper ores.

Monazite.—Monazite is reported to occur in a muscovite pegmatite near Keidorus, in a tributary of the Fish river, associated with a black uranium mineral of doubtful identity, but possibly euxenite or some closely allied mineral. Monazite is not recorded from the stream deposits of the Protectorate, but an examination of the pre-Cambrian areas would doubtless prove its presence in the alluvial deposits.

Salt.—In the neighbourhood of Elizabeth Bay and some miles from the coast, there is a bed of rock-salt which is said to form an extensive plateau, bordered on the southern side by cliffs from ten to twenty feet high. A specimen of this rock-salt was found to contain 84 per cent. of sodium chloride, and 14·8 per cent. of insoluble matter. Small amounts of sulphate and magnesia were present, and a trace of lime, but no potash could be detected. No potash minerals have been found in the deposit.

Tantalite.—Tantalite occurs in pegmatites at Tonkerhoek (Donkerhuk), associated with apatite and beryl. Quartz and felspar are the predominant minerals, but tantalite is found in columnar crystals of large size, intergrown with quartz and felspar. It is of interest to note that pegmatite veins of this type occur also in the region near the border of Bushmanland and Little Namaqualand in the north-western part of the Cape Province, Union of South Africa. Much of the Cape material appears to be columbite, however, and to what extent this is true also of the "tantalite" of German South-West Africa remains doubtful in the absence of physical and chemical data.

Tin Ore.—Tin ore is found at various localities in German South-West Africa, but chiefly in the Erongo mountains to the north-east of Swakopmund. As in some

other parts of Africa, notably Nigeria, the ore occurs partly in pegmatites that are associated with granite intrusions, and partly in the surface alluvium that has arisen from the disintegration of these pegmatites. In these deposits the cassiterite is associated with quartz, felspar, mica, topaz, garnet, tourmaline, monazite, and wolframite. Where the pegmatites are in close proximity to the granite intrusion, tourmaline is abundant.

The chief localities are those in the south and north-west of the Erongo mountains, including Onguati, Ameib, Okombahe, and Neineis. The stanniferous pegmatites are found over a wide area in this region.

The mining of the pegmatites has not hitherto proved successful, and the tin ore has been obtained almost wholly from the surface gravel. The output is steady, but small, and from what is known at present of their extent, the working of the gravels is expected to prove remunerative for some years to come.

During the first half of 1913, the exports of tin ore amounted to 101 tons of concentrates, valued at £16,340 (cf. table of exports on p. 260).

Tungsten Ore.—Wolframite occurs in pegmatite veins that traverse granite some 10 or 12 miles south-east of Little Karas and about 2 miles from the railway line running from Seeheim to Kalkfontein in Great Namaqualand. The wolframite is associated with chalcopyrite and molybdenite. The surface gravels in the vicinity of the pegmatite veins also contain wolframite.

Wolframite is found in the form of radiating masses in granite at Ubib and Goagas in the Swakopmund district. It is reported to occur also in the pegmatites of the Erongo mountain area.

Vanadium Ore.—At Tsumeb-West, in the Otavi district, a deposit of mottramite (a vanadate of copper) occurs, and the deposit has been worked to some extent as a vanadium ore. Mottramite is also found, and has been worked to some extent, on the Rietfontein farm.

The mineral vanadinite occurs in the lead-copper ore body at the Tsumeb mine.

Animal Production

Importation of Breeding Stock.—This work, which is so important in a country where stands of stock have had to be introduced for the foundation of an animal industry, has been hindered through the restriction of imports owing to the prevalence of disease in Germany. The importations of cattle have been made chiefly from the Cape Province of the Union of South Africa; in 1911, 3,900 cows and heifers were obtained from that country and distributed free to farmers of the north and middle districts or sold well under cost price, the deficit being recovered by the Government from the funds raised by a lottery. Large importations of sheep from the Cape have also been made; but they were much smaller in the year mentioned, owing to an outbreak of sheep-pox in Gibeon, Maltahöhe, and Rehoboth. Later, restrictions, originated as a means of protection against East Coast fever, stopped the supply of cattle from the Cape. Importations of karakul sheep from Europe have been made in order to supply an increasing demand. Success has been obtained also with importations of Angora goats and wool-bearing sheep, and premiums have been granted to importers of these animals; the Merino sheep shows a fair resistance to conditions arising through drought.

The importation from Cape Province of good ostriches for breeding was begun in 1909–10, and has continued since to a varying extent.

Farming and Stock-keeping.—To encourage stock-breeding the Government has given premiums for the importation of first-class breeding animals. In the grassy northern regions farmers have preferred the black cattle of the plains; whilst in the south, the severe climatic conditions have favoured the African red races. Reports show that little has been done in the way of methodical breeding; progress has been hindered through the selection of animals for breeding according merely to personal liking of the type chosen, widespread ignorance of the means and methods of breeding, the attempt to introduce into herds, by breeding, better qualities of meat or milk pro-

duction, without a corresponding improvement in the food, and the keeping of young animals in the herds. Nevertheless, some progress has taken place in the middle districts and the north; and more trouble is taken in selection among the African red cattle, which already give a fair milk and meat production, make good draft oxen, and naturally withstand the conditions of the country.

Much interest has been taken in the breeding of wool-bearing sheep, but the prevalence of sheep-rot hinders the proper stocking of farms, and in many cases there is a lack of labour. Karakul sheep have suffered severe losses from nematoid worms (Strongylus), which are especially large in July to October, when water is scarce and the pastures poor; nevertheless, there has been good progress with this race, as well as with its crossing with ordinary woolly sheep, although the depletion of the pure-bred herds by loss from disease and other causes has forced many farmers to use half- or seven-eighths-bred rams. The inter-breeding of karakul sheep and fat-tailed sheep has given good results (cf. this BULLETIN, 1914, **12**, 119). In 1911–12 the breeding of Angora goats and of woolly sheep was extended, and more good animals were imported; this, in spite of various difficulties met with, the chief of which are the severe droughts, which affect mainly the south and to a smaller extent the middle districts of the east. In order to attain greater success it is necessary to provide reserves of good food for the dry season, and dipping tanks (as a measure chiefly against sheep-rot), and also to instruct the natives in the proper tending and feeding of wool-bearing sheep. For the production of mutton, African and Persian sheep have received special attention.

Pig-breeding has extended quickly, with a consequent decrease in the importations, for slaughtering, of pigs from Cape Town; the best results have been obtained where maize is most plentiful. There is much want of proper control and of the economical employment of the by-products of the dairy for feeding; the animals are often left largely to feed themselves.

The breeding of horse-kind has extended chiefly in the southern districts and in Windhuk, the middle districts

having at first provided the chief areas for the industry; both horse-breeding and the production of mules have been assisted by the importation of good animals by the Government and by premiums from the same source. Good progress in horse-breeding has been general, in spite of the losses both by the Government and private owners through leopards and disease (chiefly strangles, introduced from native horses through lack of fencing, and the so-called "niewezieckte"), and the difficulties consequent on the burning of pasture in the dry season. In 1910–11 many farmers turned their attention to the production of mules, and encouragement was given by the Government in the form of assisted freights for good horses or asses. Progress has not been entirely satisfactory, however, because of the lack of proper animals for the production, and because most breeders hope to gain a greater profit from horse-breeding, not realising that with studs of small value they cause much injury to this industry in the Colony.

By 1910–11 much interest was being taken in ostrich-breeding; in Swakopmund special efforts were being made in the provision of irrigated fields of lucerne for feeding, and the industry was begun in Windhuk, a Government breeding farm being created at Otjituesu in this district, where in 1911–12 twenty-four adult birds, worth £1,700, were imported from the Union of South Africa. A further importation of two pairs of South African breeding ostriches was made at this farm in 1912–13, and different farmers also introduced valuable birds. At the farm the birds only gave one laying in 1911, apparently because of the long drought during the breeding season. It is stated that the first feathers cut from the birds on this farm appeared to be in no way inferior to those from the parent birds, and the opinion is given that it seems to be demonstrated that rational ostrich-breeding will meet with success in the Colony.

Poultry (geese, ducks, turkeys, fowls, and pigeons) are raised to an increasing extent; and there are a few bee-keepers.

A summary of the activities of the Government in

providing stations for assistance and instruction in stockbreeding is contained in this BULLETIN (1912, **11**, 472).

On April 1, 1913, there were altogether 1,331 farms in private possession, of which 108 were held on lease. The total area of the 1,331 farms was 33,096,404 acres, of which 1,138, with a total area of 28,451,857 acres, or 86 per cent. of the whole area of the farms possessed privately, were being worked. On the same date there were 337 small settlements with a total area of 9,234 acres, and of these 180, having a total area of 1,750, were lying fallow. The chief small settlements are those of Osona, where there has been planting activity for some time, chiefly in the raising of tobacco.

Diseases of Stock.—Of cattle diseases, splenetic fever is distributed throughout the north and south, and is also found in sheep and other small stock; it occurs sporadically. Symptomatic anthrax (black-quarter) is also sporadic, and the extent to which it is known among the natives points to its frequent occurrence in the past; the prevention and remedies are careful watering of stock, the prompt burial of dead animals, inoculation, and instruction about the disease. Investigations show that red-water in cattle (Texas fever) is not unknown in Hereroland, but there is little loss; although the tick (*Boophilus decoloratus*) carrying the disease is found in Grootfontein, the disease has not appeared there. Losses occur from time to time in most farms from biliary fever, plant poisoning, lamzieckte, and stijfzieckte; the last two are confined to the Kalahari chalk formation of the east, and extension of these diseases to the areas in the primitive mountain formations of the western districts has been nowhere experienced; they are not infectious, and yield to no internal remedies whatever; the Hereros have a useful method of control in removal to fresh pastures, and this indicates the expediency of the creation of feeding reserves. There has been little appearance of lung sickness in the Colony itself; cases imported into the neighbourhood of Etoschapfanne from

Ovampoland in 1912–13 were slaughtered, and for some time all cattle coming from the north, whether for draft or breeding, were detained at the boundary and killed. Anaplasmosis (gall-sickness) of cattle appears now and again. Rigorous measures against the introduction of East Coast fever have been taken by an Ordinance of 1910, controlling the importation of cattle, hides, horns, hoofs, and hay from neighbouring countries. Infectious pleuro-pneumonia of cattle, at one time widespread and serious, has caused very little loss in recent years.

As regards diseases of horses, "horse-sickness" has increased, chiefly in the middle districts of the country and especially Windhuk. There is a small mortality from glanders, particularly in Swakopmund; trials of the mallein treatment have been inconclusive, whilst the best method of control of the disease appears to have been the discovery of infected herds by the eye-test and their destruction. The country appears to be fortunate in that epizootic and ulcerous lymphangitis have not been reported. Strangles has appeared, more especially in the Government breeding establishment at Naucha.

In spite of the dry climate, catarrhal fever of sheep (blue-tongue) causes serious loss, and has hindered the extension of Merino-breeding. The most important disease of sheep is "rot," which has threatened dangerously the breeding of wool-bearing sheep; it is endemic in the African fat-tailed sheep, and the indolence and neglect of the natives provide additional sources of infection, whilst the quick recovery of the affected animals where there are rain and good pasture leads the farmers to suppose that the condition is not true rot and prevents them from taking proper measures, such as the provision of dipping tanks, which are badly needed. Information concerning sheep-pox is contradictory, and the latest opinion seems to be that early cases reported as the disease were not true sheep-pox. Strongylus is fairly widespread.

The diseases of pigs, swine fever and swine plague,

are claimed to have been imported from the Cape. They have been combated by early recognition of the disease and isolation of the affected animals, as well as by disinfection of the soil and the provision of new quarters for the animals. Among small stock, the diseases that have received chief attention have been pneumonia and the conditions caused by stomach worms. Spirochætosis is common, but not dangerous, among poultry; the tick (*Argas persicus*) carrying the disease is found everywhere and its control is mostly neglected. Isolated cases of the poisoning of sheep and goats, through their eating the plant *Urginea sanguinea*, have been reported from the north and north-east, and there is some loss of stock through snake-bites.

Plant Production

The greatest development in agriculture has taken place in the middle districts and the south of the country, especially where irrigation is possible, although dry farming has received increasing attention. The possibility of obtaining good supplies of water from artesian wells is one of the most favourable indications for useful plant production; in the north the rainfall alone is sufficient for many crops. Of ordinary crops, maize and potatoes are raised chiefly, but not in quantities sufficient to supply the demand and to lower the high prices that obtain; lucerne is being increasingly produced under irrigation, especially for feeding stock. Sorghum, beans, and food-melons also receive attention.

Tobacco is chiefly grown and prepared in the small settlements of Osona, where there have been attempts at the production of a "Turkish" cigarette tobacco, in addition to the pipe tobacco mainly receiving attention and in much demand in the country. This work has been assisted by the investigations at the Government Station, Okahandja.

Cotton of good quality has been grown experimentally (see this Bulletin, 1904, **2**, 259), but so far it has not been cultivated on a commercial scale.

The production of fruits has gone hand-in-hand with

the cultivation of the grape-vine; chiefly under irrigation, although the rainfall of the north gives scope for extension under a natural water supply. The production of wine seems to offer good prospects with increased irrigation; vineyards have suffered chiefly from the depredations of birds. Of fruits, peaches, apricots, and apples have given plentiful crops, leaving something to be desired in quality; pears and cherries have so far shown little success.

Under the conditions which obtain in German South West Africa, activity in the direction of forestry has been confined to the making of forest nurseries with the main object of providing material for plant distribution; these have been situated at Windhuk, Okahandja, Grootfontein, Gobabis, and Gibeon, and include some of the experimental gardens mentioned in this BULLETIN (1913, **11**, 474); the extent of their work is indicated by the fact that the distribution from them in 1912–13 was over 46,000 young trees, of which nearly one-third came from Windhuk. There is in addition a forest station at Ukuib, chiefly devoted to date-palm cultivation.

Among the dry-country forest trees grown at the forest stations, some of which, *e.g.* the eucalypts, are destined to provide pit timber for use in the mining industry, are Peruvian pepper tree (*Schinus molle*), *Prosopis juliflora*, *Robinia pseudacacia*, *Acacia cyanophylla*, *A. saligna*, *Eucalyptus rostrata*, *E. resinifera*, *E. corynocalyx*, *Casuarina tenuissima*, *C. muricata*, *Ailanthus glandulosa*, cork oak (*Quercus suber*), mulberry (*Morus alba* and *M. nigra*), *Cupressus sempervirens*, *C. horizontalis*, *C. pyramidalis*, *Pinus canariensis*, *P. halepensis*, *P. pinea*, and *P. pinaster*.

For the compilation of the agricultural portion of this article the Imperial Institute is much indebted to Mr. A. H. Kirby, B.Sc., Assistant Director of Agriculture, Southern Provinces, Nigeria.

The following table shows the quantity and value of the chief exports from German South-West Africa during 1911 and 1912, together with the chief countries of destination in 1912.

Product.	1911.		1912.		Chief countries of destination in 1912.
	Tons.	£	*Tons.*	£	
Grains, legumes, and other such food-stuffs	5	157	25	618	Germany and Union of South Africa.
Wood and other forest products	4	48	77	788	Union of South Africa.
Live animals . . .	—	2,276	—	2,671	Union of South Africa and Germany.
Horns	12	1,227	10	1,200	Germany.
Hides and skins of goats and sheep	199	12,321	234	14,889	Germany, Union of South Africa, and U. Kingdom.
Skins of wild animals	5	1,703	3	1,479	Germany.
Mohair	—	—	10	881	Germany and U. Kingdom.
Sealskins	1,577 pieces	2,177	1,769 pieces	2,078	Germany and Union of South Africa.
Wool	64	3,709	146	7,483	Germany.
Ostrich feathers . .	595 lb.	3,990	1,206 lb.	4,851	Germany and Union of South Africa.
Guano	67	415	1,468	2,315	Germany.
Meat stuffs . . .	15	727	33	1,449	Germany.
Diamonds, uncut .	153,572 grams.	1,151,707	202,834 grams.	1,520,704	All to Germany.
Copper ore, raw .	26,829	171,435	41,638	314,670	United States and other countries not specified in the returns.
" " dressed	636	16,250	450	11,493	All to United States.
Tin ore	—	—	9	470	All to Germany.
Lead	1,152	1,447	562	753	Not specified.
Marble	14	62	244	998	All to Germany.
Total exports . .	—	1,428,662	—	1,951,767	—
Total trade (imports and exports)	—	3,693,760	—	3,576,712	—

THE CULTIVATION AND PREPARATION OF COFFEE

At the present day coffee is cultivated in most tropical regions of the world, and to some extent also in certain sub-tropical countries. The importance of the industry may be judged from the fact that the value of the world's annual production of coffee is about £60,000,000. Considerable interest is being taken in the crop in many British tropical possessions which have not hitherto participated in the trade to any extent, and the present article has been prepared with a view to providing

those who contemplate growing the crop with a brief outline of the cultivation of the plant and the preparation of its product.

THE PRODUCTION OF COFFEE

Coffee first came to be used to any extent in Western Europe about the middle of the seventeenth century, the produce coming at that time from Arabia. Once the value of the crop became known, its cultivation spread rapidly in many tropical regions, the West Indies and Java becoming successively the chief centres of production. Later Brazil took the first place in the output of coffee, and at the present time over three-quarters of the world's production is grown in that country. The present position of British possessions in relation to other producing countries may be seen from the following table which shows the exports of coffee from the chief coffee-growing countries of the world in the last year for which statistics are available.

Exporting country.	Year.	Quantity. cwts.	Value. £
BRITISH POSSESSIONS:			
India	1914	356,905	1,384,242
Jamaica	1912	89,586	274,731
Federated Malay States	1913	14,486	25,437
Uganda	1913–14	12,252	23,167
East Africa Protectorate	1912–13	3,032	11,071
Queensland[1]	1912–13	1,178	4,947
Nyasaland	1913–14	1,721	4,802
British Guiana	1913	798	2,318
Ceylon	1913	187	612
Sierra Leone	1913	152	598
FOREIGN COUNTRIES:			
Brazil	1912	14,263,386	46,558,000
Venezuela	1912–13	1,197,708	3,440,865
Porto Rico	1913	—	1,773,190
Guatemala	1909	—	1,763,255
Java and Madura	1913	567,060	—
Hayti	1913	514,231	—
Mexico	1911–12	479,862	1,382,993
Salvador	1912	—	1,381,460
Colombia	1911	367,000	—
Costa Rica	1913	256,196	741,890
Nicaragua	1913	236,200	—
Angola	1913	96,062	—

[1] *Figures of production.*

Exporting country.	Year.	Quantity.	Value.
FOREIGN COUNTRIES (*continued*):		cwts.	£
Arabia[1]	1909	92,300	282,725
Ecuador	1910	77,490	153,592
Hawaii	1913	26,133	102,684
German East Africa	1912	30,880	95,168
Guadeloupe	1912	18,728	90,065
Abyssinia[2]	1913	93,770	68,507
Dominican Republic	1913	20,641	51,415
Liberia	1912	13,520	47,456
Madagascar	1913	—	33,181
Sumatra (East Coast)	1912	10,540	—
Honduras	1912–13	—	17,135

[1] *Consular District of Hodeidah.*
[2] *Consular Districts of Harrar and Gambela.*

CONSUMPTION OF COFFEE

By far the most important consuming country is the United States, which takes about two-fifths of the total world's production, Germany following next in order, absorbing about one-sixth of the total, and then France, Austria-Hungary, Netherlands, Belgium, and Sweden. So far as consumption per head of population is concerned, the Netherlands, Sweden, Norway, and Belgium are the most important countries, the United Kingdom occupying a very low place amongst European countries in this respect. This country imports considerable quantities of raw coffee, as well as much smaller amounts of roasted and ground coffee, but most of it is re-exported; the total quantities and values of the coffee imported during the last three years, and the amounts entered for consumption, are as follows:

	Imports.		Entered for consumption.
	cwts.	£	cwts.
1912	673,982	2,518,521	259,551
1913	846,918	2,923,083	260,396
1914	1,036,939	3,580,093	269,043

The consumption per head in the United Kingdom has decreased from 1·02 lb. in 1866 to 0·65 lb. in 1910, but during this period there has been a corresponding increase in the consumption of tea from 3·42 lb. to 6·39 lb. per head. Practically every other European country, on the other hand, has increased its consumption of coffee in recent years, more particularly Germany, Spain, Denmark, France, Sweden, and Russia.

The estimated consumption of coffee per head in some of the chief countries of the world in 1909 was as follows:

	lb.		*lb.*
Netherlands	15·3	Austria-Hungary	2·6
Sweden	13·1	Italy	1·6
Norway	12·6	Greece	1·6
Belgium	12·3	Spain	1·4
United States	11·5	Turkey	1·4
Denmark	9·3	Portugal	1·3
Switzerland	7·5	Canada	1·1
Germany	7·5	United Kingdom	0·67
Cape Province	7·0	Australia	0·53
Orange Free State	6·8	Natal	0·35
France	6·0	Russia	0·24
Transvaal	3·5	New Zealand	0·23

The Species and Varieties of Coffee

Coffee belongs to the genus *Coffea* (Natural Order, Rubiaceæ), which includes about forty species, native to the tropics of the Old World, chiefly Africa. Of these comparatively few are of value as a source of coffee, the two most important being *C. arabica*, L., the Arabian coffee, and *C. liberica*, Hiern, the Liberian coffee. The chief characters of these and some others which have been introduced into cultivation are dealt with below.

Coffea arabica, L.—This plant is now usually regarded as native to the mountains of Abyssinia, whence it was introduced to Arabia in early Mohamedan times. It is at the present time by far the most widely cultivated species, and occurs in many varieties and forms, the true Arabian or Mocca coffee being usually regarded as the type.

C. arabica is an evergreen shrub which, when allowed to grow naturally, reaches a height of 15 to 18 ft. It has a central tap root bearing lateral branches, many of which are quite near the surface of the soil. The sessile, pointed leaves are arranged in pairs on the slender, slightly drooping branches, and are 3 to 4 in. in length. The flower-buds are formed in clusters in the axils of the leaves. The white, fragrant flowers are open for only a short time, varying from 12 to 36 hours.

The ripe fruits or "cherries" are dark crimson in colour, slightly elongated, and circular in cross-section. In the case of the Ceylon variety they are about $\frac{3}{4}$ in. long and a little over $\frac{1}{2}$ in. in diameter. The outer part consists of fleshy pulp, like a cherry, and inside are two seeds surrounded by a hard, dry husk, known as the "parchment." The seeds develop in close contact with one another so that one side becomes flat; occasionally, however, only one seed comes to maturity, which then becomes spherical and forms the "peaberry" coffee of commerce. Between each seed and the parchment is a thin pellicle known as the "silver-skin."

Numerous varieties of *C. arabica* have been described, but in most countries the various races have never been studied systematically, and it is impossible to give anything like a complete account of all those in cultivation. Jumelle (*Les Cultures Coloniales: Plantes alimentaires*, 1901, p. 352) enumerates the following forms in addition to the true Arabian or Mocca coffee, but some of these must be regarded rather as geographical groups, each comprising a number of distinct varieties, than as true varieties.

1. "Vermelho."—A red-fruited coffee much grown in Central America; it is more robust than the type.

2. "Amarello."—A yellow-fruited form with a rather bitter taste, known in Brazil as "Botucatu."

3. "Maragogipe."—A very vigorous type which produces seeds almost as large as Liberian coffee and of excellent quality. It is grown to a small extent in Brazil, and has been introduced into South India. It is sometimes regarded as a hybrid between *C. arabica* and *C. Laurentii.*

4. "Leucocarpa."—A white-fruited plant found originally in Sierra Leone. Watt has called attention to the fact that this form may possibly be a special species of that country and not a cultivated race of *C. arabica.*

5. "Soufrière."—A very hardy plant that resists insect pests. It produces seeds much larger than those of the type.

6. "Leroy of Réunion" or "Pointed Bourbon."—This is hardier than the type; it has short branches crowded with leaves and the seeds are pointed at one end.

7. "Mysore."—The branches are ascending and the seeds round and heavy, but the yield is irregular.

8. "Coorg."—This has large, flat seeds.

9. "Java."—The branches in this case are less horizontal than the type.

According to Misson, the chief forms grown in the State of São Paulo, Brazil, in order of importance, are "national" or common coffee, which occupies about three-quarters of the plantations, "Bourbon," which occupies about one-fifth of the plantations, "Botucatu," "Maragogipe," "Java," and "Murta," the last-named being regarded as a degenerate form of "Bourbon."

Four races of *C. arabica* are recognised under cultivation in Yemen, the principal coffee-growing region of Arabia: (1) "Matari," which produces a small seed and is cultivated in the district between Menakha and Souk-el-Khemis at an altitude of about 6,000 ft.; this yields the finest Arabian coffee; (2) "Haïni," which much resembles the preceding, but yields a larger seed; (3) "Cheresi"; and (4) "Cohlani." The last two produce coffee of very good quality, but inferior to that of "Matari" (*L'Agric. Prat. de Pays Chauds*, 1912, **12**, ii, 331).

A number of varieties occur in Abyssinia, which fall into two classes, (1) "Harrari," the finest Abyssinian coffee, which is grown in Harrar and Tchertcher at an altitude of 5,000 to 6,000 ft., and (2) "Abyssinian," which occurs chiefly in Ilou-Babor, Sidamo, Goffa, and Ouallaga.

The varieties of *C. arabica* grown in Java have been carefully studied by Cramer, who distinguishes fifteen kinds (*Med. Dep. Landb.* No. 11, 1913, Batavia). These he arranges under the following headings:

(1) *C. arabica typica.*

(2) Varieties with small leaves: *Mocca*, *laurina* ("Bourbon"), *Murta*, *monosperma*, and *polysperma*.

(3) Varieties characterised by the colour of the fruits: *purpurascens* ("orange coffee"), *amarella* ("golden-drop coffee"), *variegata*, *bullata* ("Djamboe coffee"), and *angustifolia*.

(4) Varieties with characteristic growth-form: *erecta* and *pendula*.

(5) Varieties with vigorous growth: *Maragogipe* and *columnaris*.

Coffea liberica, (Bull) Hiern.—This species is found wild along the West Coast of Africa from Sierra Leone to Angola, and has been introduced into many other parts of the world in the hope that it would prove more resistant to disease than *C. arabica*. These hopes, however, have not been altogether realised, although it has proved to be more robust than the latter species, and, generally speaking, grows better at low elevations. Its cultivation has made most headway in the Dutch East Indies, where much work has been done on its improvement. There is little prospect, however, of much extension in its cultivation, except in certain regions less suited to *C. arabica*, as the product is generally regarded as inferior to Arabian coffee.

The plant differs from *C. arabica* in many respects. It is a larger shrub, sometimes attaining a height of 30 ft. or more, its branches are stouter and more erect, and its leaves much larger. The fruits are about an inch in diameter, and do not drop so readily when mature as those of *C. arabica*.

A coffee grown in Java, which differs in some respects from *C. liberica*, has been distinguished by Cramer under the name *C. Abeokutae*.

Coffea robusta, Linden.—Although known everywhere by planters as "robusta" coffee, this species should probably be more correctly called *C. Laurentii*, De Wild. It occurs wild in the Belgian Congo and other parts of Central and West Africa, but its cultivation on a commercial scale has been almost confined to the Dutch East Indies. An account of the plant and its cultivation has already been published in this BULLETIN (1912, **10**, 454), and no further reference to it need be made here.

Coffea stenophylla, G. Don.—This plant, known as the Highland coffee of Sierra Leone, is also a native of West Africa. It has been grown experimentally in Trinidad, Java, Ceylon, India, and elsewhere. It grows freely, yields abundantly, but is longer in coming into bearing than *C. liberica*. It gives a highly-flavoured bean somewhat like Mocca coffee.

Coffea excelsa, Chev.—This coffee occurs wild in Central Africa at an altitude of over 2,000 ft., and has been introduced into cultivation in Java, Belgian Congo, Tonkin, and French Guinea. It has given good results in Java, being exceedingly robust, and four to five year old trees have yielded well. The coffee is of good quality, a small consignment of the Java product having been sold in Holland at a price equal to Java *arabica* coffee.

Coffea congensis, Froehner.—This species inhabits the river banks of the middle Congo and Ubangi districts of the Belgian Congo. It yields a coffee of good quality, and, as it is said to be resistant to Hemileia disease, it has been introduced to cultivation in some parts. Particular attention has been devoted to the variety *Chalotii* in Madagascar.

Coffea canephora, Pierre.—This is also a Congo coffee. It is a very variable species, the best-known variety being *Kouilouensis*, which yields the Quillou coffee.

Hybrid Coffee.—Where more than one variety of coffee is grown natural hybridisation may often take place. Unless selection is systematically carried out the plants raised from seeds produced in this way soon revert to one or other of the parents as a rule. In many countries, however, definite attempts have been made to improve the plant by artificial hybridisation. Hybrids between Arabian and Liberian coffee have been raised successfully in Java, which are said to combine the good qualities of the two plants, and in one case it is claimed that when such a hybrid is grafted on Liberian roots the plant is resistant to coffee leaf disease. Hybrids between *C. liberica* and *C. robusta*, and between *C. congensis* and *C. liberica*, have also been raised successfully in Java. A hybrid between " Bourbon " and " Maragogipe " has been produced at the Agricultural Institute of São Paulo, Brazil, which is said to possess the robustness and disease-resistant character of the latter variety combined with the productiveness of the former. It has been found to retain these characters after several generations, and young plants have been distributed to a number of estates.

There is still room for considerable improvement in the coffee plant, especially in regard to regularity of yield, and

this result is most likely to be achieved by hybridisation and subsequent careful selection.

Coffee Substitutes.—In addition to the true coffee plants, others whose seeds are roasted in the countries of origin as a substitute for coffee are often designated "coffee." Among these may be mentioned Kentucky "coffee" (*Gymnocladus canadensis*, Lam.), and Negro "coffee" (*Cassia occidentalis*, L.), both belonging to the natural order Leguminosæ, and Mussaenda "coffee" (*Gaetnera vaginata*, Lam.), which is related to true coffee, and is sometimes included in the same family. Numerous substances are employed for adulterating or mixing with coffee, chicory being largely used for the latter purpose in this country, whilst a number of "artificial" coffees have been placed on the market, especially in Germany and the United States. An account of the various adulterants and so-called substitutes is given in *Kaffee, Kaffeekonserven und Kaffeesurrogate*, by E. Franke (Vienna, 1907), and in *Bulletins* No. 13, Pt. 7, and No. 32, *Div. of Chem., U.S. Dept. Agric.*

Cultivation

Climate

The first consideration in selecting the site of a coffee plantation is the climate. The natural habitat of the various species of coffee, so far as this is known, is along water courses and in the partially wooded country which borders the forest areas of tropical Africa; that is to say in situations where the atmosphere is more or less humid and the temperature fairly high. Both these conditions are essential for successful coffee cultivation, and it is necessary to consider them in some detail.

Temperature.—Speaking generally, coffee does best where the mean annual temperature is about 70° F., the mean minimum about 55° F., and the mean maximum about 80° F. At Bragança, one of the chief centres of coffee growing in the State of São Paulo, Brazil, the mean annual temperature is 66·9° F., the mean during the summer months 72° F., and during the winter 60·8° F.; the absolute maximum and minimum temperatures recorded during a period

of 10 years were 97·7° F. and 32° F. respectively. In the coffee-growing region of Yemen, Arabia, the temperature varies from 57° to 79° F. during the day, falling to 72° during the night in summer; in winter it may fall as low as 28° or 30° F. on the summits. In Uganda, where coffee has been successfully grown in recent years, the mean maximum and minimum temperatures are 80° F. and 62° F. respectively, with only little variation during the year.

Rainfall.—In order that the humidity of the atmosphere may be maintained the rainfall must be moderately high and fairly evenly distributed throughout the year. Prolonged drought is fatal to the coffee plant, although it is an advantage if a dry season supervenes during the winter. These points are well brought out in the case of Bragança, where the mean rainfall during spring, summer, autumn, and winter is 15·3, 25·5, 23·8, and 4·5 in. respectively, the total amount in the year being 69·1 in. In Yemen the rainfall is somewhat irregular, but here also the heaviest rains fall during the summer, November to March being the driest season; the annual rainfall here varies from about 32 to 78 in. If the rainfall is too heavy the plant is apt to make much growth at the expense of flowers and fruit, especially at low levels.

Altitude.—Coffee, particularly the Arabian variety, requires an open and bracing climate and a clear sky. For this reason it grows best at fairly high altitudes, the actual height being determined to a large extent by the latitude. At lower levels, if the atmosphere is damp, Arabian coffee is very liable to disease, and at such places Liberian coffee succeeds best. The finest-flavoured coffee is, as a rule, grown at the highest altitudes, where the climate is usually drier, but the yield and the size of the fruit are correspondingly decreased. The chief coffee-growing districts of Brazil are situated on plateaux seldom less than 1,800 ft. high, whilst in Arabia the plantations are situated at altitudes varying from 3,500 to 6,000 ft.

Wind-belts.—Strong winds are very detrimental to coffee, even more than a dry atmosphere or low rainfall. Localities subject to violent winds should therefore be avoided, but even in other places it is often advisable to plant

wind-belts to protect the plants. The trees selected for this purpose should be strong and densely branched. They may be planted close together and thinned out when necessary. The following have been recommended as forming good wind-belts: *Markhamia platycalyx*, *Ficus* spp., conifers, jak fruit (*Artocarpus integrifolia*), mango (*Mangifera indica*).

Shade Trees.—Closely connected with the climatic conditions is the question of shade for the mature plant. Whether this is necessary or not has been much discussed, but the general conclusion reached is that it depends entirely on the local conditions, and each planter must decide the matter for himself, either by studying the results obtained on neighbouring plantations, or by actual experiment. In certain regions, such as parts of Arabia and Mexico, which are comparatively arid, shade is necessary to prevent desiccation of the surface soil, and to maintain a humid atmosphere. In other countries, however, it may be not merely unnecessary, but even harmful, the atmosphere being thereby made too damp, and consequently favouring the development of fungoid disease, inducing rank growth, and perhaps spoiling the flavour of the product. In Central America and the northern States of South America, where shading is much in vogue, the trees mainly employed belong to the Leguminosæ, and it has been suggested that any good results which may be obtained through having such trees on the plantation are due not so much to the shade produced as to the enrichment of the soil by these plants. For a full discussion of the question of shade, O. F. Cook's "Shade in Coffee Culture" (*Bulletin* No. 25, 1901, *Div. of Botany*, *U.S. Dept. Agric.*) may be consulted.

As a general rule shade is necessary for the seedlings in the nursery and for newly planted bushes, a point which will be considered further when dealing with the propagation and transplanting of coffee, but in certain countries—*e.g.* parts of Uganda—coffee has been raised from seed, transplanted, and brought to maturity without shade of any kind.

If shade trees are employed in the plantation much care

should be taken in their selection. Those with a fairly high crown, and which do not cast a deep shade, are preferable, the best being leguminous trees. O. F. Cook (*loc. cit.*) gives a very complete list of trees which have been used or recommended for the purpose, among the more important being *Erythrina* spp., *Pithecolobium Saman*, *P. dulce*, *Inga* spp., *Albizzia Lebbek*, *A. moluccana*, and *Gliricidia maculata*, all leguminous plants; and *Artocarpus integrifolia*, *Mangifera indica*, *Persea gratissima*, *Musa* spp. (banana and plantain), *Hevea brasiliensis*, and *Castilloa elastica*, all of which yield products of economic value, and may thus form an additional source of revenue. In Java *Leucaena glauca* is much in favour as a shade tree, and for this purpose appears to be replacing *Erythrina* and *Albizzia*.

Soil and Situation

To obtain the best results the coffee plant requires a rich, deep, well-drained soil, rich in humus. Stagnant water is fatal to the plant. The most suitable situation for a plantation, therefore, is on gently undulating land possessing a loamy soil overlying a porous subsoil. Heavy clays, light sands, or very chalky soils should be avoided; on slightly sandy soil good results may be obtained, provided it is rich in humus, so that plenty of moisture is retained, or as long as the rainfall is heavy and fairly evenly distributed throughout the year. Rocky soils with pockets of rich soil, are, perhaps, the most suitable, since, although they may present some difficulties to lining and holing, they are generally well drained and cool, and the rocks themselves form an almost inexhaustible reserve of food which is continually becoming available to the plants by the action of the weather. Some of the best coffee produced in Arabia, Java, India, and elsewhere is grown on soils of this type.

A good indication of the fertility of the soil may be obtained from a study of the indigenous vegetation. The presence of tall, straight trees implies as a rule a deep, rich soil with an ample water supply; on steep slopes, however, the soil, although still rich, is sometimes thin,

owing to denudation by heavy rains. Land bearing short grass with only occasional scrub or low trees should be avoided. In Uganda the presence of a high growth of "Elephant grass" is said to indicate a deep, rich soil, well drained.

On steep land trenches must be made across the slope to check erosion and to retain the water, whilst on wet lands drains must be cut. The latter should be about 15 to 18 in. wide and deep, about 50 ft. apart, and have a fall of about 1 in. in 12, or 1 in. in 16, according to the nature of the ground.

Although the soil itself must be well drained, it is imperative that the plantation should be formed close to an abundant and permanent water-supply, since large quantities of water are required in the preparation of the coffee for the market, and are usually necessary for watering the seed-beds and the young plants in the nursery.

Propagation

On a commercial scale coffee is almost invariably raised from seed; cuttings root readily, but this method is only possible on a small scale, whilst in certain cases grafting has been employed. The practice which is sometimes followed of planting an estate with seedlings which spring up round mature trees rarely gives good results. Such plants are never uniform in size, their roots are frequently malformed, and the planter has no control over the quality of the product. The purchasing of young plants is also to be condemned, unless they come from an absolutely reliable source. Without question the best results are obtained by raising the plants from seed.

The seeds are most commonly sown in nurseries, but sometimes they are planted at stake. In the latter case three or four seeds are sown together on specially prepared mounds of soil in the situation where the adult plant is to grow. After germination all but the strongest plant on each mound are pulled up. This method is only practicable where there is no chance of drought at the sowing season.

Preparation of Nursery.—The first consideration in the formation of a plantation is to select the site of the nursery. If the area to be planted is large, it is preferable to form several nurseries in different parts of the estate, so that the young plants when ready to be moved may be transplanted as rapidly as possible. The soil should be the best on the estate, rich, porous, containing plenty of humus, and situated on a gentle slope close to a good water supply. Any forest trees in the neighbourhood of the nurseries may be left, as they will provide shade and shelter, but they should not be allowed to overhang the seed-beds.

The seed-beds should not exceed 5 ft. in width, so that they can be readily tended, and should be separated from each other by a trench about 9 in. deep and 18 in. wide, which acts both as a path and as a drain. A deeper trench should be made along the top of the beds to prevent any danger of surface-wash. The soil must be thoroughly well tilled, all stones and roots removed, and the surface reduced to a fine state of tilth before the seeds are sown. It is better not to add manure, except in the case of poor soils, which of course will not be selected if better are available, but sand may be added to advantage to make the soil more open.

Selection and Sowing of Seed.—The seed used for sowing should be obtained only from specially selected plants. Bushes about eight years old, in full bearing, yield the best seed, and care should be taken to see that they give a regular and large yield of the finest-quality coffee. The largest fruits, situated about in the middle of the branches and half-way up the bush, should be selected and allowed to become perfectly ripe before being picked. The pulp is removed by hand, but the parchment should not be broken. If the seeds cannot be sown at once, they must be carefully and slowly dried in the shade to prevent them from shrinking, and then packed thinly in layers between sand in a wooden box and stored in a cool place, shaded from the sun. Seeds may be safely kept in this way for several months.

The most suitable time for sowing is the beginning of the rainy season. In some cases the seeds are placed about 6 in. apart in rows, and the seedlings left in position

until they are ready to be moved to the plantation. More usually, however, they are sown thicker than this, and the seedlings pricked out into specially prepared beds. In the latter case drills are made about 7 or 8 in. apart, and about 1½ in. deep, running down the length of the beds. If the soil is not sufficiently good about ½ in. of fine soil is put in the drills and the seeds are then planted by hand, convex side uppermost, and about 1 in. apart. The drill is then filled in with fine soil which is pressed firmly down. Sometimes two or three grains of wheat, maize or other cereal are sown at intervals along the drill; these germinate before the coffee and serve to indicate the position of the drill and so enable watering to be more efficiently carried out and weeding to be performed without injury to the coffee seeds.

The quantity of seed sown should be more than sufficient to supply the immediate requirements of the plantation, since gaps will require to be filled up, and some allowance must be made for failures in germination. As a guide to those who have to purchase the seed it may be mentioned that there are roughly 2,500 coffee seeds to the pound.

After-care of the Nursery.—Coffee seed usually takes about six or seven weeks to germinate, and during this time the soil must be kept moist and shaded, and all weeds must be rigorously kept down. If the rainfall is insufficient artificial watering must be resorted to, or a mulch of dead leaves may be placed on the soil, but this must be removed as soon as the first seed-leaves make their appearance. Shade is usually provided by placing mats, palm leaves, interlacing grass leaves, or similar material, on a wooden framework about 2 ft. from the soil.

When the seedlings have formed two or three pairs of leaves they are pricked out into beds, prepared in a similar manner to the seed-beds, at distances of about 12 in., in rows about 15 in. apart. Some planters recommend pricking out the seedlings even younger, viz. before the two seed-leaves have unfolded.

If the soil in the seed-bed is at all dry, it should be

watered the day before the plants are shifted, and it is usually necessary to water them immediately after planting. The young plants must be well shaded until they have taken root. If the plants are to be grown in the plantations without shade they must be hardened to exposure by gradually removing the shade over the beds some time before they are ready for transplanting.

Grafting.—This method of propagation has been practised to some extent in Java, more especially in connection with certain hybrids raised there. Good results have been obtained by using *C. liberica* as a stock—the plants for this purpose being raised in nurseries in the usual way—this species having a vigorous root system which is less affected by certain soil parasites, such as eel-worms, than are those of other forms. Old trees which have become attacked by coffee leaf disease or which fail to give good yields are sometimes rejuvenated by grafting. In such cases the stems are cut down to within 8 or 9 in. from the soil and two branches allowed to grow, which serve as stocks on which a hybrid or other good type of coffee is grafted.

Transplanting

The coffee plant is ready to be planted in its permanent quarters when about a year old. At that age it will be about 12 to 18 in. high and possess the first pairs of primary branches. Several months prior to transplanting, however, lining and holing must be completed. The distance of planting will depend on a number of factors: the kind of coffee grown, the character of the soil and climate, the size to which the plant is to be allowed to grow, and so on. Speaking generally, it may be said that Liberian coffee should be planted about 12 ft. by 15 ft., and Arabian about 6 ft. by 8 ft., these distances being increased when the more vigorous varieties are grown, on rich soils or in moist climates.

On good soils the holes should be about 12 to 18 in. in diameter, and the same in depth, but on poorer or stony soils they should be larger. The earth removed is some-

times placed in a heap on the higher side, but some planters recommend spreading it evenly over the surface of the ground. After a time fresh soil, often mixed with manure, is put into the hole so as to form a slight mound, in the centre of which the seedling is planted.

Planting should only be commenced after the soil has been thoroughly soaked by the rains, the best time being on showery or dull, cloudy days. In removing the plants from the nursery as large a ball of earth as possible should be taken up round the roots. After planting, the earth must be pressed firmly down, and if dry weather follows one or two waterings must be given. In any case, it is necessary to shade the plants with leafy branches, or by other means, to prevent them from wilting. The whole of the planting should be completed well before the close of the rainy season in order to give the plants a chance of getting well rooted before the dry weather sets in.

It is a good plan to place a number of seedlings in pots, as these bear transplanting well even during dry weather, and may be used to fill up gaps in the lines.

Planting with Stumps.—As previously mentioned, the establishment of a plantation by means of young plants purchased elsewhere is not to be recommended, and should only be practised when it is impossible to form a nursery. Plants two to three years old are used in this case. The stems are shortened to 8 or 10 in., and the roots trimmed. The stumps are then planted at an angle of about 45° in holes prepared in the same way as for seedlings. All buds which appear on the lower side should be rubbed out, and the strongest shoot on the upper surface left to form the new stem of the plant.

Maintenance of the Plantation

The chief operations to be carried out after the plantation has been formed are weeding, tillage, manuring, and pruning. The first two may be conveniently performed at the same time, and they will therefore be considered together.

Weeding and Tillage.—It is necessary that the ground should be kept quite free from weeds, since they not only

take up nourishment from the soil, but, if allowed to get too bad, may choke the young coffee plants. It is best, therefore, to begin weeding as soon as the land has been cleared. Annual weeds may be simply hoed up and allowed to wither on the surface, but those with underground stems or runners must be rooted up and burnt, whilst succulent kinds, which can resist desiccation for long periods, should be buried. Much labour may be saved in future years if weeding is done every three or four weeks for the first year or two, as by this means the weeds can be removed before they flower and produce seed. No hard-and-fast rule can be laid down as to the number of weedings which should be done in later years—that depends entirely on local conditions, but the weeds should never be allowed to get out of hand.

There is some difference of opinion as to whether the land should be tilled. On steep slopes there is certainly a danger of erosion if the surface soil is loosened, but, on the whole, the advantages of tillage greatly outweigh the disadvantages. By keeping the surface soil open evaporation is lessened, and air, which is necessary not only to the roots of the coffee but also to the micro-organisms which play such a great part in determining the fertility of the soil, is enabled to circulate freely.

While the plants are young, and there is no danger of injuring their roots, the soil may be dug deeply between the lines, but later on the soil should be loosened with a mamoty or hoe to a depth of 3 or 4 in., by which means most weeds will be removed. On some estates in Brazil a cultivator drawn by a horse is employed while the trees are young, but although the cost of labour is thereby lessened, there is the chance of some of the weeds being left.

Manuring.—On virgin soil it is not necessary as a rule to apply manure until the trees begin to bear, but thenceforth the fertility of the soil must be judiciously maintained. The most important plant constituents taken up from the soil by the coffee plant are nitrogen, potash, and phosphoric acid. The annual requirements of 1,000 plants of coffee at different ages in respect of these sub-

stances, according to Dafert (quoted by Lalière, *Le Café dans l'État de Saint Paul*, 1909, p. 122), are shown in the following table:

Age.	Nitrogen. *lb.*	Potash. *lb.*	Phosphoric acid. *lb.*
First 4 years	8·87	23·62	2·49
From 5 to 8 years	35·70	76·92	19·57
From 9 to 20 years	28·87	45·83	15·76
After 20 years (old trees)	5·09	30·53	9·48

These figures must not be regarded as absolute, but they serve to emphasise the fact that when the plants commence to bear the amount of food required increases considerably. Further, it does not follow that the above amounts must be added in the form of manure each year, since much depends on the natural fertility of the soil, especially as regards the quantity of insoluble potash and phosphoric acid. The kind of manure which is required may be ascertained in a number of ways. A rough idea may be obtained by noting the appearance of the plants: if the shoots are few, and the leaves weak and pale in colour, it is a sign that nitrogen is lacking; if the general growth is good and the flowers abundant but the fruits few and malformed, there is probably a deficiency of potash; whilst drooping plants, producing a normal number of shoots but small, malformed seeds, indicate poorness in phosphoric acid. A chemical analysis of the soil is an excellent guide, but needs the interpretation of an expert. The surest method of all is by experiment, small areas being marked out and manured in different ways, the crop from each being harvested and prepared separately in order to obtain accurate results.

It is very important that the amount of humus in the soil should be ample, for it not only serves as a source of nitrogen but improves the texture of the soil and retains moisture. It may be provided in the form of stable manure, prunings from the coffee bushes, leaves, weeds, green manure, etc. The material is usually laid on the surface as a mulch, which will keep the soil cool and moist in hot weather and prevent surface wash to a large extent during heavy rains. Sometimes the manure is buried in

trenches or holes dug between the lines of bushes, but if it is dug in under the plants the surface must only be lightly forked so as not to interfere with the roots. The best green manures to employ are leguminous plants, which enrich the soil with nitrogen. Those most commonly employed in Brazil are the haricot and the white lupin, whilst the velvet bean (*Mucuna utilis*) has found much favour there in recent years. In Java hedges of *Leucaena glauca* are sometimes planted between the coffee; at intervals of about 15 ft. the trees are allowed to grow to their normal size in order to provide shade, but the remainder are cut down each month to about 4 in. from the ground and the prunings applied to the land. Other leguminous plants which may be grown as green manures are pigeon pea (*Cajanus indicus*), ground nut, species of *Crotalaria*, *Indigofera*, *Phaseolus*, *Vigna*, *Tephrosia*, etc. Apart from their value as manure these crops are beneficial in preventing surface wash on slopes.

In addition to the natural manures already mentioned, others commonly employed on coffee estates are bones, oil cakes, fish manure, guano, wood ashes, and coffee pulp, and other refuse from the preparation of the beans. The last named is of considerable manurial value, but to prevent loss of its manurial constituents it must be carefully stored. The following table shows the proportion of manurial constituents present in such refuse, consisting of pulp, parchment, etc., as received from the factory, and in similar material after exposure to rain and sun for several months (Dafert, quoted by Lalière, *loc. cit.* p. 125).

		Fresh material.	After exposure to rain and sun for several months.
		Per cent.	*Per cent.*
Moisture		17·80	46·78
Nitrogen	N	0·86	0·85
Phosphoric acid	P_2O_5	2·55	0·18
Potash	K_2O	8·09	0·94
Lime	CaO	9·54	0·44

A compost of high manurial value may be made by placing the pulp, mixed with bone meal at the rate of 1 cwt. per ton of pulp, together with sweepings and general estate rubbish, in layers in a pit, covered with about 6 in.

of soil, and allowing the whole to rot for about six months, being protected in the meantime from rain and sun.

Opinions differ as to the advantage of using chemical manures for coffee, but on the whole these should only be used to supplement cattle dung and other natural manures. Among those employed are superphosphate of lime, basic slag, sulphate of ammonia, nitrate of lime, sulphate of potash, nitrate of potash, kainite and lime, as well as mixed manures containing varying proportions of nitrogen, phosphates, and potash. The use of chemical manures is becoming increasingly urgent in Brazil owing to the scarcity of cattle dung, and experiments conducted in São Paulo have fully demonstrated their value. As a result of an extensive series of experiments conducted on plantations in Guatemala, it was concluded that although the application of organic manures is indispensable in coffee culture, the best plants and largest returns are secured by the additional use of a complete chemical manure (see *Tropenpflanzer*, 1908, **9**, Beihefte 4, p. 185).

Whatever manures are employed they should be applied systematically. Anstead ("Coffee, its Cultivation and Manuring in South India," *Bulletin* No. 6, 1915, *General Series, Dept. Agric. Mysore*, p. 30) mentions an instance where, in an experimental trial, the crop was doubled in a period of four years by an organised system of manuring based on a careful soil analysis. This author recommends that small estates of say 40 acres should be divided into four equal blocks and that each block should be manured each year on a definite plan extending over a series of years. As an example he suggests that the following manures should be employed:

(*a*) Slaked lime at the rate of 1 ton per acre.

(*b*) Cattle manure, compost or fish, at the rate of 4 cwts. per acre.

(*c*) A mixture of two parts basic slag and one part sulphate of potash, at the rate of 4 cwts. per acre.

(*d*) A good mixed manure at the rate of 4 cwts. per acre.

These could be applied in rotation to the different blocks as follows, but the system can of course be varied in many ways.

	1st year.	2nd year.	3rd year.	4th year.
Block I. . . .	(*a*)	(*b*)	(*c*)	(*d*)
Block II. . . .	(*b*)	(*c*)	(*d*)	(*a*)
Block III. . . .	(*c*)	(*d*)	(*a*)	(*b*)
Block IV. . . .	(*d*)	(*a*)	(*b*)	(*c*)

Pruning.—To obtain the maximum yield it is necessary to encourage the growth of new flowering shoots. This can be done by judicious pruning, but as great damage may be caused by bad pruning only skilled workers should be employed for the task. In some parts, however, the trees are allowed to grow naturally, the only pruning done being to cut out dead and diseased wood.

The term pruning, as applied to coffee, really consists of three operations, topping, pruning proper, and handling. In topping, the terminal shoot of the main stem, consisting of a bud and a pair of young leaves, is removed. This is usually done when the plant is about 5 ft. high, but sometimes when only 2 to 3 ft. high. In the latter case the sucker, which grows out near the top, is topped when about 1 ft. long, this process being continued until the plant is about 5 ft. high. Watt suggests that the terminal shoots of the top three or four primary branches should also be nipped out, the object of this being to prevent them growing too luxuriantly and splitting the main stem by their weight.

The pruning proper is usually carried out a few weeks before the resting period of the tree, and after the crop has been harvested. In order to allow air to circulate freely, all secondary branches within 6 in. of the main stem are removed. Those shoots which have borne fruit are cut out, as well as dead and diseased wood, branches which are growing towards the centre of the tree or across other branches, and all tertiary branches. The secondary branches formed on the primaries are those which bear fruit, and to ensure all the fruit being properly nourished and developed it is usual to remove one of every pair of secondaries on alternate sides, leaving the stronger where possible. Pierrot (*Cult. Prat. et Rat. du Caféier*, p. 50) suggests the following method of pruning, but points out that its true value can only be ascertained by experiments carried on over a sufficiently long period : The

shoot at the end of its first year's growth is cut back, leaving two pairs of leaves. This results in the formation of two branches in the axils of the terminal leaves. One of these is cut back as before at the end of a year's growth; the other is allowed to grow for three years, when it is removed completely. Each pair of branches which arise after a shoot is cut back is treated in the same manner as the first pair.

Soon after topping or pruning a number of superfluous shoots usually make their appearance, and these must be removed as soon as possible by simply rubbing or pinching them off with the fingers—a process known as handling. A second or third handling is necessary before the crop is harvested, but in these cases care must be taken not to remove the shoots which are needed for flowering in the following season.

During the pruning and handling the stems should be cleaned of moss, lichens, etc., in order to allow the air to get to the bark and to destroy insect pests.

Catch Crops

During the first year or two after planting, catch crops, such as maize, beans, sesame, ground nuts, etc., may be grown in rows between the lines. They should not be planted so as to interfere with the roots of the coffee, nor after the coffee begins to bear. Besides being a source of revenue, tall growing crops, such as maize, afford shade to the young coffee.

Harvesting the Crop

The coffee tree first flowers as a rule when three years old, but the crop is then small. In Brazil the crop produced in the fourth year is about sufficient to cover the cost of collection; it increases in the fifth year, and a full crop is produced in the sixth year. The yield then increases annually, reaching its maximum between the fourteenth and eighteenth years, but then gradually diminishes until the end of its life, which, on the average, extends to forty years. In Uganda the first or "maiden" crop is gathered in two and a half years from the time of sowing, the

first full crop being obtained when the plants are three years old.

The fruits take about seven months to come to maturity, but since the flowers open at different times the fruits are not all ready to pick at any one period. The time when they are ready for picking depends to a large extent on the climate. In the State of São Paulo, Brazil, the harvesting commences early in May and usually extends to September. In Uganda there are two main crops, the larger commencing to ripen in September and the other in March, but picking is in progress during every month from February to November. In Java three crops are gathered annually, the most important being the second, which begins to ripen at the commencement of the rains. In India the fruits ripen from October to January.

The method of gathering the crop depends in large measure on the climate. In dry countries, such as Arabia, the fruits are allowed to ripen completely so that they fall to the ground naturally, or by slightly shaking the branches. In moister climates they are frequently pulled off the tree and placed straight away into baskets or sacks. In the latter case it is important that only fully ripe fruits be gathered, the others being left for a later picking. Two methods are used in Brazil. The ordinary method is to allow the fruits to fall to the ground after the latter has been cleared of weeds, leaves, twigs, etc.; the berries are then separated from small stones and earth by sifting. In the second method, a cloth is spread beneath the tree to catch the fruits, which are thus kept clean. At one time the latter method was only employed on rough ground from which it was difficult to gather the fruits, but the introduction of the wet method of preparing the coffee necessitated its use elsewhere, since a clean product is essential in this process.

Yield.—The amount of coffee produced by a tree depends on its age, on the kind of coffee, on climatic conditions, on the fertility of the soil, and other factors, so that the yield not only varies in different countries, but from year to year on the same estate. In Ceylon a yield of 1 lb. of cleaned, saleable coffee per tree was regarded as

a high average. On the other hand, an average of 5 lb. of marketable coffee per tree was obtained during a period of eleven years on an estate in São Paulo, the maximum during this period being 8½ lb., and the minimum a little over 2 lb. per tree; the number of trees in full bearing on which this estimate was based varied from 180,000 at the beginning to 380,000 at the close of the period. Brown and Hunter (*Planting in Uganda*, London, 1913) give the average yield of marketable coffee in Uganda as 2 lb. per tree (based on the yield of nearly 27,000 trees).

Pests and Diseases

The coffee plant is subject to the attacks of a considerable number of insects and fungi, but comparatively few of them do serious damage. The severity of the attack may be minimised to a large extent by foresight on the part of the planter. A carefully weeded estate, and one on which all dead wood is removed from the trees, always suffers less than one in the same locality which is not properly tended. The planter too should always be on the look-out for the appearance of disease; as soon as a plant is found to be attacked the diseased part should be cut off and burnt, and in certain cases the whole plant should be rooted up and burnt, neighbouring plants being treated with a fungicide in order to prevent the disease from spreading. In the following pages only the more important coffee pests and diseases are dealt with.

Insect Pests

Scale Insects.—These have proved serious pests to coffee in practically every country in which the crop is grown. They are minute insects which are covered with a shell-like scale which adheres closely to the surfaces of leaves and shoots. They multiply rapidly, and it is necessary, therefore, to apply remedial measures as soon as the pest makes its appearance. One of the most widespread species is *Lecanium viride*, known in Ceylon and India as green bug, while another common in those countries is *L. hemisphaericum*, the brown bug. In East Africa *L. africanum* and species of *Ceroplastes* are the most prevalent on

coffee. These pests may be kept under control by maintaining a vigorous growth of the trees by good cultivation and manuring, by removing all trees and plants in the neighbourhood of the plantation which are known to harbour the insects, and by thoroughly spraying the coffee as soon as the pest appears. In Uganda a solution of whale-oil soap at a strength of 1 lb. to 5 gallons of water has been found to be a very effective spray, but a resin wash is most commonly employed in India and elsewhere.

The scale insects excrete a form of honey-dew, upon which a black mould ("sooty mould") frequently lives. The latter only affects the nutrition of the plant by preventing the sunlight from reaching the surface of the leaves; it may be destroyed by the spray used against the scale insect.

Borers.—There are a number of insects the larvæ of which damage the coffee tree by boring into the wood of the branches and stems. Affected trees, if not treated in time, are either killed outright or they are broken off by the wind owing to the extensive tunnelling. The most important of these borers are the Indian coffee borer (*Xylotrechus quadripes*), occurring in Southern India and Ceylon; shot-hole borers (*Xyleborus coffeae* and *X. compactus*), the former found in Java and Tonkin and the latter in German East Africa and quite recently in Ceylon; the white coffee borer (*Anthores leuconotus*), which is one of the worst enemies of coffee in East Africa; the orange-headed coffee borers (*Nitocris princeps* and *N. usambica*) found in Uganda and German East Africa respectively; and the West African coffee borer (*Monohammus sierricola*), which is widespread throughout West Africa and the Belgian Congo; in addition to these, all of which are beetles, the larva of a moth (*Zeuzera coffeae*) known as the red coffee borer, does extensive damage in India, Ceylon, Java, and German East Africa.

The presence of a borer is usually indicated by the presence of debris on the ground under the tree, or on the surface of the branch. All affected branches should be cut off and burnt, and if the tunnels are found to enter the stem an attempt should be made to extract the larva with

a piece of wire. If this fails a drop or two of carbon disulphide or carbon tetrachloride should be injected into the hole, which must then be sealed with wet clay, while any other holes visible in the surface of the stem should be similarly sealed.

Fruit Fly.—This insect, *Ceratitis capitata*, is the Mediterranean fruit fly, the larva of which attacks almost every kind of fruit, especially those of the Citrus genus, and which occurs throughout the tropics and sub-tropics. Affected coffee fruits yield an inferior bean, and many of them drop off prematurely. The eggs are deposited just under the skin of the fruit, and the larva spends all its life inside so that its presence is only detected when the fruits drop off. As the larva enters the ground to pupate it is necessary to gather up and burn the fruits as soon as they fall, if necessary twice a day, in order to destroy the pest. Attempts to capture the adult flies by placing tins containing kerosene on the branches, which is said to attract them and kill them as soon as they come in contact with it, have met with varying success.

Leaf-miner.—In all coffee-growing regions, with the exception of India, Ceylon, and Java, and particularly in the West Indies and Brazil, the coffee leaf is mined by the larva of a small moth, *Cemiostoma coffeellum*. As a general rule it does not cause much damage, but if it should become a serious pest, the adult may be trapped by means of lamps; badly affected leaves should be picked off and burnt, and in others the grub may be killed in the leaf by squeezing the latter between the fingers.

Coffee Berry Beetle.—This is a minute insect, *Stephanoderes coffeae*, which attacks coffee in Uganda, Belgian Congo, and German East Africa. Both the grub and the adult beetle live within the fruit, and the pest can be kept under control by picking and destroying the affected berries.

Leaf-eating Insects.—Numerous beetles and caterpillars feed on the leaves of coffee, but as a general rule do little damage. Such pests can be kept in check by

spraying with an arsenical insecticide or with lead chromate.

Grasshoppers and Crickets.—These sometimes do extensive damage, particularly in nurseries and newly planted plantations. They may be most easily destroyed by the use of poisoned bait.

Fungoid Diseases

Coffee Leaf Disease.—This disease, the most dreaded of all those attacking coffee, is found in almost every country of the Old World where coffee is grown, but so far it has not made its appearance in the Western Hemisphere. It is caused by a fungus, *Hemileia vastatrix*, Berk. & Broom, belonging to the Uredineæ, and related to the rust of wheat. The disease first became evident in Ceylon in 1869, and spread with such rapidity and caused so much damage that many estates had to be given up, with the result that the cultivation of the plant, at one time the most important industry in the island, now occupies a relatively low position. The disease next made its appearance in Southern India, and has since been found, as already mentioned, in other parts of the Old World, but nowhere has it wrought such havoc as it did in Ceylon.

The fungus attacks the leaves chiefly, but may also occur on the young shoots or on the fruits. The first indication of the disease on the leaves is the appearance of more or less circular, discoloured spots, which gradually increase in size and become pale yellow, and finally, on the under surface, bright orange in colour. The effect on the plant is that the leaves drop prematurely, only a few fruits ripen properly, and in severe cases the whole tree may be killed.

So far no cure has been found, and the planter must therefore apply measures to prevent the disease spreading. This consists of cutting off and burning all diseased shoots, and spraying the trees with Bordeaux or Burgundy mixtures; dusting the leaves with sulphur and lime has been tried, but with disappointing results. All fallen leaves should be raked up in heaps and

burnt. The fungus produces two kinds of spores; those formed first, the uredospores, have a comparatively thin coat and are more easily killed by fungicides than the later ones, teleutospores, which have a thicker coat and are adapted to withstand adverse conditions. It is essential, therefore, in order to get the best results, to commence spraying as soon as the disease makes its appearance.

Certain species of *Gardenia*, *Vangueria*, and other genera of the Rubiaceæ are attacked by *Hemileia*, and to lessen the chance of infection from these wild plants it is advisable to destroy any which may occur in the neighbourhood of the plantation.

Reference has already been made to the attempts to introduce or to produce disease-resistant varieties of coffee. Some of these have given promising results when first introduced, but it is too early yet to definitely recommend any one of them.

American Coffee Leaf Disease.—The cause of this disease is *Sphaerostilbe flavida*, Mass. (= *Stilbum flavidum*, Cke.), an ascomycetous fungus related to that producing the East Indian canker disease of cocoa. At present it is confined to the New World, having been recorded from Brazil, Costa Rica, Porto Rico, Guatemala, Venezuela, Nicaragua, Dutch Guiana, etc. The fungus produces circular, whitish spots on the leaves, up to ¼ in. in diameter, and also attacks young shoots and fruits. The effect on the plant is much the same as that produced by *Hemileia*, and within a short time from the first appearance of the disease an entire plantation may be denuded of leaves. The remedial measures recommended for *Hemileia* may be employed in this case also, particular care being taken to burn all diseased fruits, for it seems likely that infection is due to the spores produced on these and not to those formed on the leaves or shoots. Spraying with Bordeaux mixture has proved efficacious in preventing the disease from spreading to healthy trees.

Black Rot ("*Kole-Roga*").—This disease, which is fairly common in India, is caused by *Pellicularia koleroga*, Cke. It occurs also in Trinidad, Surinam, Porto Rico, and else-

where in the West Indies, and a disease similar in character has been reported from Venezuela. The leaves and fruits become covered with a slimy, gelatinous layer of fungal hyphæ, turn black and fall. Being entirely superficial, this fungus may be combated by spraying with Bordeaux mixture; dusting with sulphur has been recommended, but this proved ineffective in Porto Rico.

Coffee Leaf Spot.—This disease, also known as berry spot, is caused by *Cercospora coffeicola*, Berk. & Cke. It has been reported from Central and South America, and probably occurs throughout the American coffee-growing regions. Both leaves and berries are affected by the disease. On the former it causes large blotches on the upper surface, which are at first dark brown and later become greyish and dead; the spots ultimately appear on the lower side. Similar spots appear on the fruits, being especially common on the nearly ripe berries, the largest spots occurring on the upper side. The effect on the fruit is serious, as the fleshy part becomes fastened to the parchment, thus making the process of preparation difficult, and reducing the quality of the product. It has been stated that the disease may be prevented in its worst form by providing sufficient shade.

Root Disease.—A disease which appears to be widespread in coffee-growing regions attacks the roots of coffee, occasionally doing considerable damage. In many cases the fungus causing the disease has not been determined, but in some it has been ascribed to a species of *Rosellina*. The roots of affected trees are found to be covered with a white or brown mycelium. All diseased trees should be uprooted and burned and the soil in their neighbourhood treated with lime, which should be forked in. To prevent the disease spreading to healthy trees, a trench 2 ft. wide and deep should be dug round the affected area, and any roots of the healthy trees which are seen to be covered with the mycelium of the fungus should be cut off and burned.

Die-back Disease.—A disease which has made its appearance in Uganda quite recently, and has caused much harm on some plantations, is described in the *Annual Report, Dept. Agric., Uganda*, 1913–14. The affected branches begin to die back from the tips and the leaves fall. The trouble

progresses towards the main stem, the bark of the branch cracks, and after the death of the twig small open cankers develop in many cases. The berries fail to ripen, and turn brown, but remain on the branch. Eventually the tree dies and presents a dried-up appearance, the wood being brittle; the root system of trees killed in this way is generally poorly developed.

The trouble is most prevalent on trees which have suffered from *Hemileia* disease, or are placed in unsuitable soil, or are from any other cause of low vitality. The cause of the die-back is not clear, and is still under investigation. The Botanist to the Department of Agriculture states that a fungus, *Capnodium brasiliense*, is present on the exterior of affected parts, while small unbroken pustules on the bark contain spores of a fungus which may prove to be *Colletotrichum coffeae*. On the other hand, the symptoms are similar in many respects to those of the pink disease of the Para rubber tree due to *Corticium salmonicolor*.

Attempts to arrest the disease at the Kampala Plantation by cutting off the affected branches well beyond the live parts failed. On one plot the immature berries were picked off, the branches well pruned, and kainite applied to the soil at the rate of 400 lb. per acre, and later a dressing of cow-dung was given. By this means the die-back was arrested, and the trees grew luxuriantly, which seems to indicate that the disease is constitutional rather than due to an external agency.

Other Diseases.—Among other diseases attacking coffee, mention may be made of a canker said to be caused by *Necator decretus*, which has been reported from Malaya; a leaf disease, *Colletotrichum coffeae*, occurring in Uganda; pink disease, *Corticium salmonicolor*, identical with that which attacks Hevea and cocoa; and the root disease, *Hymenochaete noxia*, which causes considerable damage to Hevea in some countries.

Eelworm Disease

One of the most serious diseases affecting coffee in Brazil is caused by an eelworm (*Aphelenchus coffeae*, Noack), which is present also in Costa Rica, and possibly

other parts. The tap root is mainly attacked, becoming swollen, and covered with thickened, rugged bark, but the lateral roots may also be affected. In the case of full-grown trees the leaves on young shoots become yellowish-green and shrivel, the shoots themselves turning black and wilting. After a time the tree dies. Young trees, on the other hand, may die without showing any of these symptoms. All affected trees must be dug up and burnt, and the ground treated with carbon disulphide. As the disease spreads very rapidly through the soil, it is advisable to isolate the infected area by means of a deep trench.

Preparation of Coffee

Two methods are employed in converting coffee fruits or "cherries" into saleable coffee, viz. (1) the dry method and (2) the wet method. The former is the more primitive and is still practised to a certain extent in some countries, but the second method is preferable and should be employed if possible.

(1) *The Dry Method*

This method has the advantage of being serviceable when cherries in different stages of ripeness have to be handled at the same time, owing to the crop ripening irregularly, and labour being scarce or dear, so that successive gatherings are impracticable, or to the lack of a good supply of water. Its success, however, is dependent on the continuance of fine weather over a fairly considerable period.

The gathered cherries are spread in a thin layer on open drying grounds or barbecues. These should if possible be made of brick or cement, although clay will serve. The cherries are turned over, made into heaps, and spread out again, to ensure even exposure to the sun. After the first two or three days, when the coffee is beginning to dry, it should be placed under cover at night if dews are prevalent and exposed again on the drying floor the next day. It is also necessary to protect the coffee from rain. If only small quantities are being dried the cherries may be exposed on small wooden trays which

can be easily handled and carried bodily under cover when necessary. When the cherries become quite dry, which even under good conditions usually takes about three weeks, they may be stored.

The next stage is to remove the dried husks from the cherries. This may be done by threshing with a flail or by pounding in a large mortar, the particles of shell and dust being removed by winnowing. The threshing or pounding, however, usually leads to the breaking of a considerable proportion of the beans, and it is preferable to use a hulling machine, which can be obtained of a size requiring either hand or mechanical power.

(2) *The Wet Method*

This is the more modern method of preparation, and is the one practised on all up-to-date plantations. It requires a fairly considerable amount of equipment in the form of buildings and machinery, and care must be taken in selecting the site for the factory. Much water is required, and the factory must therefore be situated where there is an ample and constant supply. It is an advantage if the buildings can be erected at the foot of a slope, as it is then possible to so arrange the required machinery on different floors that the fresh cherries can enter at the top of the building and pass downwards through the various stages of preparation with a minimum amount of handling. As far as possible throughout the preparation mechanical appliances should be used in order to economise the expense of labour.

To obtain the best results by the wet process the berries should be quite ripe and should be dealt with the same day as picked. The cherries, as they are brought in from the plantation, are placed in tanks of water, built of concrete and of a size proportionate to the quantity of fruit brought in daily. The ripe cherries sink, and are drawn off through a pipe in the base, but on a small scale the water may be emptied out and the sunken cherries removed.

The next stage is the removal of the pulp which sur-

rounds the beans. This is effected by special pulping machines. On a large scale the cherries are delivered directly from the tanks in a stream of water to the hopper of the pulper. The latter may be obtained in various sizes, from small hand machines to the large power-driven ones used on the large estates. Those in common use are of two types, the cylinder machine and the disc machine. In the former case the disintegrating apparatus usually consists of an iron cylinder covered with punched copper like a large nutmeg-grater, which rotates close to a pulping bar or breast. The cherries are fed by a stream of water into the hopper, which is usually fitted with a device for removing stones, and then pass through the pulping mechanism, the pulp and the beans being delivered separately. As a general rule some imperfectly pulped or unpulped cherries pass over with the beans, and these can be separated by a rotary screen or oscillating sieve, the unpulped material being re-pulped. Double machines are in use in which the unpulped cherries delivered from one cylinder are automatically separated from the beans and carried to the hopper of a second cylinder, which is specially adjusted to pulp them. Some machines are fitted with a crushing apparatus which partially pulps the cherries before the latter pass through the pulping cylinders. Great care is necessary to see that the machine is properly adjusted, and the maker's instructions on this point should be carefully carried out. If this is not done the cherries will be imperfectly pulped or the beans may be damaged.

The disc pulpers, which are said to require less water than the cylinder machines, possess one or more vertical iron discs, covered with copper, bearing solid projections. The discs rotate against adjustable pulping bars with steel faces, the beans and pulp being delivered separately as in the case of the cylinder machines.

The pulped cherries, after leaving the machine, are always mixed with a certain amount of pulp, and to remove this they are sometimes passed on from the pulper to a receptacle containing water, in which they are stirred about with poles, paddles, a revolving wheel, or other

suitable device; or they may be placed in a tank with a small amount of water so that they can be trampled upon by bare-footed men. More water is then added, the mass is stirred up, and the light pulp got rid of by withdrawing the water from above. The beans, still enclosed in the parchment, remain at the bottom of the vat, and are left comparatively free from pulp when the water is removed. If it is found that the amount of pulp present with the beans on leaving the pulper is small, this washing may be dispensed with.

The parchment in any case, however, is still very slimy owing to portions of the pulp, etc., remaining adherent to it. This material is removed by fermenting the coffee, for which process the beans are piled up in a heap under cover, or more usually placed in special receptacles. The fermentation may be carried out in the washing tank after removal of the water. When fermentation is complete the parchment coverings no longer feel slippery but are slightly rough. The exact time taken for this process may vary from one to three days, and a handful of beans should be taken out occasionally in order to ascertain when the fermentation is completed. If fermented too long the quality of the coffee will be affected.

The beans are then washed again, the parchment being now left clean. The washing may be carried out in the manner already described, or in one of the special mechanical washing machines now on the market.

The washed parchment coffee is next spread out in a thin layer (3 to 4 in. deep) on a smooth drying ground of cement or brick, and raked over several times daily at first to ensure uniform drying, or it may be placed on trays made of ¼ in. woven wire, which are supported on a framework 3 or 4 ft. high. After the first day or two the coffee should be protected from night dews and rain. If the weather cannot be depended on during the drying period artificial drying must be resorted to, for which purpose several good machines are available, while good results have been obtained in some countries by utilising flue-heated tobacco-curing barns. A good method is to partially dry the coffee in the sun and finish in a machine.

The effect of sun and artificial drying on the size of the beans is dealt with subsequently (p. 296).

The actual duration of the drying period varies. For sun-drying about ten full days' sunshine is necessary, but some kinds of hot-air driers will completely dry the coffee in twenty-four hours. It is essential that the coffee should be completely dried, as, if shipped in a moist condition, it develops a musty smell, which is difficult to get rid of. When thoroughly dry the parchment can be crumbled to dust by the fingers, and the bean is hard and cannot be dented by the finger-nail or teeth.

The next process is to remove the parchment. This operation may be carried out on the estate, at the port of shipment, or in the country to which the coffee is exported.

To effect the removal of the parchment the dry coffee is fed into a machine known as a "peeler and polisher," fitted with screw or cone rotating inside a cylinder. The parchment as well as the silver skin surrounding the bean is broken up by this means, and at the same time the beans are polished. The broken husk and dust are removed by means of a sieve and by winnowing, or by means of an exhaust fan attached to the machine.

Grading follows next, *i.e.* the sorting of the beans into various sizes. This can be done in a simple manner by sieves with meshes of appropriate dimensions, or by special sizing machines. There are several forms of the latter, and as a rule at least two are necessary in order to separate the beans into uniform grades. In London the usual grades are peaberry (the spherical beans), bold (the largest flat beans), medium, and small.

The question as to whether the planter cleans and grades his coffee or exports it in the parchment, is one which he must decide for himself on the conditions obtaining locally. It may be mentioned, however, that Uganda coffee cleaned and graded in London has, in certain cases at least, proved to contain a larger proportion of the higher grades than coffee cleaned in Uganda, and, moreover, the London cleaner can grade according to the demands of the market. Brown and Hunter (*Planting in*

Uganda, London, 1913, p. 170) point out that two consignments consisting of identical sun-dried coffee, shipped at the same time, one cleaned in London and the other in Uganda, yielded the following percentages of the different grades :

	Peaberry.	Bold.	Medium.	Small.
Uganda cleaned .	9·41	6·22	46·87	37·50
London cleaned .	6·00	56·00	20·00	18·00

The difference in price between bold and medium was about 3*s.* per cwt., so that the advantage in this consignment was enormously in favour of London grading.

The same authors also quote comparative figures relating to sun-dried and artificially-dried coffee. Two consignments were shipped together and were precisely similar, except that one-half was sun-dried and the other machine-dried. The percentages of the grades obtained when cleaned in London were as follows :

	Peaberry.	Bold.	Medium.	Small.
Sun-dried . .	3·13	26·56	35·94	34·37
Artificially dried .	5·35	58·03	21·45	15·17

These figures show that artificial drying results in less shrinkage of the bean than sun drying, and consequently a very large increase in the higher grades.

Before the graded coffee is put on the market, it is usually hand-picked in order to remove discoloured and faulty beans. On a large scale the beans are delivered on to a travelling band, the defective beans being picked out by the operator, the good coffee being delivered into a bag.

The coffee is shipped in bags, double bags being used in some cases, and each consignment should be sent off as soon as it is ready, as the coffee deteriorates in appearance, and consequently realises lower prices if stored for some time.

NOTES

Oil-Seed Industry of Bombay.—A large amount of useful information is given by Y. G. Pundit in his *Report on the Oil-pressing Industry of Bombay* (Govt. Central Press, Bombay, 1914). The author visited the various districts in which oil seeds are grown, and investigated the methods of manufacturing oil and oil-cake in Bombay and Sind. The production of oil seeds is large, about 400,000 acres being under such crops in 1912, and it is considered that considerable extension might take place, especially by the adoption of more scientific methods of agriculture. The seeds principally used are sesame, linseed, kurdee (safflower), rape, jambho (*Eruca sativa*), ground nuts, castor, and niger seed, but coconuts, mowra, and hemp seeds are available in some localities. At present most of the oil is expressed by means of crude native pestle and mortar mills (ghanis), often driven by bullocks, although improved ghanis worked by oil engines are coming into use, while modern machinery, especially the Anderson expeller screw machine, is becoming more common. In spite of the good local demand for oils, particularly edible oils such as cotton seed and ground nut oils, and oil-cakes, most of the attempts to establish large-scale oil mills have failed, generally owing to the lack of technical and commercial knowledge on the part of the management, and failure to realise the necessity of erecting only the best and most modern machinery and of securing efficient scientific control. Another important factor appears to be the local prejudice in favour of native-made oil-cake in preference to the machine-made article. The author suggests that attempts should be made to overcome this prejudice by demonstrating the value of machine-made oil-cake by experiments on the farms of the Agricultural Department. He also suggests that cotton seed oil might be manufactured at cotton ginneries, which frequently have power available in excess of that required for cotton ginning. The feasibility of establishing an oil-milling industry on modern lines should be demonstrated by the erection of mills by the Government equipped with up-to-date machinery and controlled on scientific lines, the mills to be sold after successful demonstration of their capability. The various aspects of the oil-seed industries are discussed fully, and the report will be of value to all who are interested in the Indian oil-seed trade, or who may contemplate the erection of mills in India.

New Sources of Meat Supply within the Empire.—Most of the conditions which a year ago made for world-wide shortage of meat supplies still remain in force, though the general outlook is obscured by the abnormal cir-

cumstances which have arisen owing to the war. Messrs. Weddel & Co., in a recent report on the prospects of the trade, state that home supplies may be capable of slight temporary expansion; Australia and New Zealand may be depended upon to maintain their output; whilst South American countries appear to be in a position to increase their aggregate production to some extent. The prospect of supplies from fresh sources, although brighter than they were a year ago, are still somewhat nebulous, if only because in most cases the quality of the animals now available is such that considerable improvement in breeding is necessary before exportation could be arranged on any large scale.

The question of the possibility of establishing an export trade in meat from South Africa has for some time past been engaging the attention of agriculturists in the Union, and a few small shipments of frozen beef from Natal to England have been made. These trial lots contained some useful beef, but the quality was irregular, and called for more careful grading. In view of the great interest taken in the possibilities of the British market by South African farmers, there is good ground for anticipating a welcome development of the supply of meat from this important source. There are naturally many difficulties to be overcome before an export trade in meat can be established, but none of these are insuperable, or are such as have not been surmounted elsewhere. The first essential factor is that there must be stock in sufficient numbers and of suitable condition and quality to maintain a regular supply of carcases. Then, slaughtering and refrigerating plant must be erected. In countries where an export trade is established, the work of preparing the carcases for shipment is undertaken by private enterprise, and the very considerable outlay involved is not incurred until the time is ripe. In this connection the Union Trades Commissioner has mentioned that the London representatives of some of the leading packing houses have expressed their readiness, when cattle and sheep are available in sufficient numbers and in fit condition, to erect packing houses in South Africa and buy the animals. Without doubt there is scope for a meat export industry in South Africa, and it may be hoped that before long some definite system will be evolved for the breeding of cattle for such an industry on a large scale.

A new industry for the West Indies, consisting in the production on co-operative lines of pork and bacon, is suggested in a paper in the *West Indian Bulletin* (1914, **14**, 221) by the Imperial Commissioner of Agriculture for the West Indies. There appears to be no reason why, as the outcome of the development of refrigerating machinery, bacon and pork products should not be raised in the West

Indies to find a market in Europe and America. The success of the industry would depend upon its being undertaken on a large scale and on a co-operative system. Companies might be formed to purchase pigs from growers on a profit-sharing basis, on lines similar to those on which the large sugar factory companies deal with sugar-canes and sugar.

There are many facilities for greatly increasing the number of pigs raised in the West Indies. Much land unsuitable for sugar-cane or cotton could be used for pig raising, and food crops of diverse nature can be easily grown, whilst many by-products, such as molasses from the sugar factories, may be utilised. In addition, bananas and coconut products which are now wasted can be fed to pigs and turned into meat. The paper states that there would be no difficulty in raising in each island 20,000 to 30,000 pigs in a season. The best breeds would probably be found to be the Duroc-Jersey, Poland-China, Berkshire, and Tamworth. It has been suggested that bacon produced in the West Indies may possess the defect known as softness. This, however, is a feature appearing not only in warm climates, but also in cold. Recent researches appear to show that softness is largely traceable to methods of feeding, and that certain oily foods, such as some maize products and oil meal, may accentuate the defect. Examination of the fat of pigs raised in several West Indian islands shows that under present conditions of feeding the fat tends to exhibit firmness rather than softness.

An account of a bacon factory in Rhodesia published in the *Rhodesia Agricultural Journal*, 1914, shows that such an undertaking as that proposed for the West Indies can be worked successfully in a warm climate. The Rhodesia factory is run, on quite a small scale, by the British South Africa Company. The pigs are bought direct, not on a profit-sharing basis as is suggested for the West Indies. The factory is a very substantial building, and the outer walls are of such a thickness that the interior is always cool. A description is given of the arrangement and equipment of the buildings and of the methods adopted from the arrival of the pigs to the moment when the bacon is ready for sale.

The Cultivation of Seaweed in Ireland.—The present scarcity of potash salts, the bulk of which, prior to the war, was obtained from the Stassfurt mines in Germany has directed attention to other sources of supply, both mineral and vegetable, chief among the latter being various kinds of seaweed. In the United States, as is now well known, considerable attention has been paid for some years past to the possibility of obtaining potash in commercial quantities from the giant seaweeds which occur off the Pacific coast, and the success which has so far been attained there is

largely due to the fact that enormous quantities of the weed can be collected readily within a small area. The seaweeds which occur round the British Isles are almost as rich in potash as those utilised in the United States, and in Scotland the weed is employed as a source of both potash and iodine, while in many parts round the coast it is used directly as a manure, especially for potatoes. At present practically the whole supplies, both for the production of potash and as manure, are obtained from naturally grown seaweeds, which are either washed up on the shore or collected by cutting at low tide. The question of increasing the supplies by cultivating the weed is one that merits serious attention, and by this means too it would be possible to provide a supply of this valuable potash manure to regions on the coast where at present, owing to the character of the foreshore, seaweeds do not occur.

The fact that seaweeds can be cultivated has been demonstrated in Japan, where the natural supply of certain kinds used for food and other purposes has been augmented in this way, and at several places round the coast of Ireland. An account of the methods practised in the latter country is given in the *Journal of the Department of Agriculture and Technical Instruction for Ireland* (1915, **15**, 546), of which the following is a summary.

The seaweeds useful as manure all grow attached to rocks and stones, and their cultivation consists simply in providing suitable anchorages, generally large stones, between tide-marks, in localities where rocks and stones are naturally absent.

At Achill Sound in Co. Mayo, the beds are situated in the shallow tidal waters and belong to those farmers whose land fringes the coast. Large stones are collected from the shore, taken out in boats at high tide, thrown overboard, and subsequently, at low water, arranged in more or less regular lines, forming rectangular beds or fields on the muddy or sandy bottom. The crop of weed is cut once in two years, and is used as a rule by the farmer owning the bed, being but rarely sold. After a time, when the stones sink into the soft substratum, they are raised by spades and crowbars.

At Mill Bay, between Greencastle and Killowen in Co. Down, seaweed beds were made many years ago by bringing granite stones from the adjacent Mourne Mountains and placing them—one to about each square yard—on the sands below tide mark. Quantities of stones are still being carted out to the sands, and there are now hundreds of acres devoted to the cultivation of seaweed in the district. As indicating the value attached to these beds, it might be mentioned that in November 1913 one measuring 38 square perches (Irish), *i.e.* about 0·4 acre, was sold for over £40. The price per ton load of the weed "on foot" averaged, in

1913, about 15*s.* to 16*s.*, but in 1914, owing to a diminished area devoted to potatoes in the district, the demand was smaller and the price per ton was only about 8*s.* exclusive of cutting and carting.

At Achill the most abundant species of seaweed is the "bladder wrack" (*Fucus vesiculosus*), mixed with which is a certain amount of *Ascophyllum nodosum*, whilst in the deeper water *Fucus serratus* occurs. At Mill Bay also the "bladder wrack" is the most abundant, *Ascophyllum nodosum* appearing on the stones later. At the latter locality the weed grows best nearest low-water mark, and here it may be cut once in two years, but higher up the shore it can only be cut with advantage once every three years.

Other well-known localities in Ireland where seaweeds are cultivated are Ardara and Carndonagh in Co. Donegal.

The Northern Territory of Australia.—Under this title a paper read before the Royal Society of Arts by Mr. David Lindsay, Leader of the Elder Scientific Exploring Expedition, is reprinted in the Society's *Journal* (1914-15, **63**, 386). The paper deals briefly with the history, natural features, economic resources, and possibility of settlement of the province. The Northern Territory forms nearly one-sixth of the whole continent of Australia and extends from latitude 26° south to 11°, and from longitude 128° to 138°, the western boundary of Queensland, the total area being 523,620 square miles. The climate on the coast is hot and humid, but the inland plateau has a drier climate and is suitable for white settlers. The wet season extends from October to April, and the dry or winter season from May to September. The winter is bracing and healthy except on the coast, and at the head of the Roper river and further south the temperature often falls below freezing point. The rainfall varies in different localities, but 200,000 sq. miles enjoy a rainfall of from 10 to 20 in. per annum, and an equal area possesses a rainfall of over 30 in. per annum.

The chief industries at present are mining and pastoral, both of which are hampered by lack of railways. The value of the output of minerals to date is over £2,000,000. In 1913, tin valued at £25,526; gold, £13,256; copper, £482; wolfram, £3,140—a total of £44,626—were exported. Only ninety Europeans and 530 Chinese are engaged on the fields. The pastoral industry has been established in various districts where there are natural permanent waters, and although profits have been small owing to the great distance from the markets, flocks and herds of sheep and cattle have increased until there are now over 450,000 cattle; 20,000 horses; 75,000 sheep, and 8,000 goats pasturing on the 107,406 square miles leased. The scarcity of labour has proved a great drawback in the agricultural development of the Territory.

The soil is suitable for the growth of rice, cotton, sugar, tobacco, and other products, but the author is of opinion that if the possibility of growing wheat on the uplands could be successfully demonstrated, the Territory would be quickly settled as the Australian farmers understand and show a strong preference for wheat-growing. He thinks that the difficulties in connection with the supply of agricultural labourers could be overcome by the establishment of reservations for the 20,000 to 30,000 aboriginal inhabitants of the Territory, who could then be properly trained and fitted for agricultural work.

The railways at present existing in the Territory consist in the north of a length of 146 miles from Port Darwin to Pine Creek, which has recently been extended to Katherine river, and in the south of a length of 688 miles from Adelaide to Oodnadatta. A gap of about 1,020 miles still remains to be bridged, and the author shows that when this is accomplished enormous areas of rich pastoral country will be opened up, especially in the vicinity of Powell's Creek. To the east of the Creek grassy downs stretch for 350 miles to the Queensland border. A part of this region is occupied by the famous Barkly Tableland, from 800 to 900 ft. above sea-level, which is stated to be capable of carrying 10,000,000 sheep. The Tableland is being developed, and is at present stocked with 200,000 head of cattle and 70,000 sheep. To the west of Powell's Creek is the great pastoral region known as the Victoria River District, a well-watered country clothed with Mitchell and other good grasses and edible bushes, and possessing a total area of about 40,000,000 acres, with a certain rainfall of 20 to 30 in. The development of a large portion of this area is being undertaken by English capitalists, who have bought the stock and leases, and are erecting freezing works at Port Darwin to enable meat to be shipped to England. To the east of Port Darwin are vast plains inhabited by large numbers of buffalo, which are shot for their hides alone. It is stated that under proper care and management the breeding of these animals should become a profitable industry, as at present the carcases are wasted.

The author describes a journey across the Territory from south to north, and shows that numerous metalliferous and mineral areas exist in the McDonnell Ranges and elsewhere which, owing to the present difficulties of transport and the high cost of all mining requisites, are still awaiting development. Owing to the fact that it is possible to pass suddenly from sandy desert to rich, park-like country, there are many scattered areas of pastoral and agricultural country throughout the Territory, in addition to those already mentioned, which are expected to open up with the building of new railways.

The Royal Commission appointed to advise as to the routes of railways and new ports necessary for the development of the Territory, have recommended the connection of Oodnadatta and Pine Creek by a line passing as nearly as possible through the centre of the Territory, with branch lines across the Barkly Tableland and up the valley of the McArthur river to a new port to be created at the mouth of the river, on the Gulf of Carpentaria. In addition, there are a number of rivers draining the northern pasture lands which could be rendered suitable for transport and for irrigation work, and it is probable that these will prove of great value in assisting the settlement of the Territory.

Surveys and classification of lands are being vigorously carried on. A careful and systematic geological examination of the mineral areas is being made, and boring for water has commenced on the stock routes. An experimental sheep farm has been established near the head waters of the Roper river, and if success be attained a large area of country which at present is only considered fit for cattle will be available for this class of stock. The inland regions are remarkably healthy for stock, and the author is of opinion that the opening of stock routes by providing water, the building of railways, and the opening of the new port, will have the effect of turning a practically unoccupied country into one of the most important suppliers of meat to the United Kingdom.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.*

Foodstuffs and Fodders

Cocoa.—The report of the Commissioners appointed last year to enquire into the causes of the alleged depreciation of Trinidad cocoa in foreign markets states that although great variations in the price obtainable for cocoa take place it cannot be laid down definitely that the price of Trinidad cocoa has depreciated if the average price for a period of five years be taken, and the most that can be said is that a change has taken place in the relative value of Trinidad cocoa as compared with that of other cocoas, because of the greater care now taken in the preparation of some of the latter (*Council Paper No.* 21 *of* 1915, *Trinidad and*

Tobago). The enquiry was held mainly on account of complaints which had been made by an American firm. Evidence was given with respect to the claying of cocoa, and with one or two exceptions the general opinion held by witnesses was that the practice had much to recommend it, if not carried to excess. It is said to prevent the beans from becoming mouldy in wet weather, to improve their market value by giving them a bright and uniform appearance, and to help to preserve the aroma of the cocoa. The Commissioners were of opinion that the evidence had shown that the method of carrying on business in the Trinidad cocoa industry was, on the whole, satisfactory. It was to be expected that individual cases of carelessness, or even of dishonesty, must occasionally recur, but no facts had been proved pointing to anything unsound and calling for comprehensive legislation in the industry. The Commissioners were however of opinion that steps might be taken to prevent the practice of overclaying. To the moderate use of clay in curing the beans the evidence showed there was no objection, but there was objection to clay being used to make weight, and this, there was reason to believe, had been done amongst small buyers. Legislation is to be introduced to give effect to the recommendation of the Commissioners that it should be made illegal to keep or use clay on premises licensed to deal in cocoa.

Wheat.—The desirability of increasing the area devoted to wheat production in Australia has been strongly urged since the outbreak of war, and in the *Agric. Gaz., New South Wales* (1915, **26**, 1), the questions of land available for the cultivation of grain and the limits of profitable wheat production are discussed. In New South Wales it is estimated that 21,000,000 acres is the maximum area which could be harvested for grain. Of this area at present only 3,140,000 acres are under cultivation for wheat. It is therefore possible to increase the area under wheat by over 17,750,000 acres in New South Wales. With a yield of 11·6 bushels per acre, which is the average of the last ten years, this would mean a harvest of 243,000,000 bushels, as compared with 38,000,000 bushels harvested in the year 1913–14. Estimates on the same lines give a possible annual production of 110,000,000 bushels for Victoria, as compared with 33,000,000 in 1913–14; 61,000,000 bushels for South Australia, as compared with 17,000,000 in 1913–14; and 129,000,000 bushels for Western Australia, as compared with 13,500,000 in 1913–14. Queensland produced 1,750,000 bushels of wheat in 1913–14, and Tasmania 350,000 bushels. The possible extension of the area under wheat is therefore estimated to be capable of increasing the production five-fold, from about 103,000,000 bushels to 540,000,000 for the four chief wheat States. The assumptions are that wheat

cannot be profitably grown with less than 10 in. of rain during the period of growth; that the proportion of land suitable to, or available for, wheat production is about one quarter of the total area within this limit; that the average yield per acre for the last ten years will be maintained; and that only four States will take part in the expansion. With regard to the last assumption it is mentioned that Queensland has enormous areas suitable for wheat production, which will undoubtedly be cultivated as the country develops. The Northern Territory is another unknown quantity, but an important addition to the wheat-growing area may be looked for when that Territory becomes developed. As regards economic considerations, railway facilities and provision for bulk handling will be important factors when the question of cultivating such large areas is taken in hand. Bulk handling is being much discussed at present.

Oils and Oil Seeds

Coconuts.—The results obtained at Mahailluppallama demonstrate the value of irrigation and thorough cultivation of coconut palms in the dry districts of Ceylon (*Rep.*, *Dept. Agric.*, *Ceylon*, 1912–1913, p. 31). Trees which had reached the productive stage on irrigated and cultivated land yielded 50 nuts per tree during nine months of 1913, while those on land not irrigated or cultivated only yielded 42 nuts; although the trees on irrigated land were only five years old while those on non-irrigated land were six years old, the former were better developed and suffered less from the attacks of beetles (*Rhyncophorus ferrugineus*).

A four-acre experimental plot of coconut palms has been established successfully in the Virgin Islands (*Rep. Bot. and Exp. Station*, *Tortola*, 1913–14, p. 12); cotton and other catch crops are to be grown and further planting is to be carried out.

Coconuts grow near most of the littoral villages of the Gold Coast and are well suited for local cultivation, but it would be inadvisable to engage in systematic planting on a large scale unless measures are taken for protection against insect pests (*Rep. Agric. Dept.*, *Gold Coast*, 1913, p. 13); 626 tons of copra, valued at £14,292, were exported in 1913, being an increase of 29 tons over the export in 1912. Plots of native and Ceylon nuts growing at the Assuantsi experiment station made good progress (*loc. cit.* p. 8). A scale insect (*Aspidiotus destructor*) was found on many young trees, and attempts have been made to establish a ladybird beetle (*Scymnus* sp.) which preys on this pest. Results of these experiments are not yet available.

Ground Nuts.—The reasons for the low prices at which Coromandel ground nuts sell in Europe were discussed at

a meeting of the Madras Agriculture and Trade Conference (*Indian Tr. Journ.*, 1915, **36**, 26). Complaints have been received as to the slow but steady decrease in oil content. Among the causes of this defect appears to be indifferent cultivation due to the high prices in former years leading cultivators to grow ground nuts continuously on the same land without attempting rotation of crops. In certain districts early harvesting, owing to the difficulty of harvesting after the rains cease and the ground becomes hard, is also a probable cause of inferiority. Further, the kernels are frequently shipped in bulk and are liable to heat. Machine-shelled Pondicherry nuts fetch a higher price than hand-shelled nuts, which are liable to suffer damage owing to the method of shelling, viz. damping and beating. A good and fairly cheap shelling machine should find a large sale among village associations. Satisfactory yields of oil (42–45 per cent.) have been given by nuts grown on well cultivated, but not excessively manured plots at the Palur experimental farm. The Anderson oil extractor is stated not to work satisfactorily with kernels, although it gives good results with whole nuts. The use of ground nut cake as a manure is increasing.

Oil Palm.—The grain weevil, *Calandra oryzae*, L., has been found by Lamborn boring into the trunk of a fire-scorched oil palm in Nigeria (*Bull. Entomol. Res.*, 1914, **5**, 214). The living tissue was attacked and sap exuded constantly, attracting ants and other insects; no other pests were found in Nigeria, but at Cotonou in Dahomey four species of *Derelomus* weevils were found feeding on the fresh male flowers.

Repeated attempts have been made in the Gold Coast to raise plants from different varieties of palm nuts, but these have been unsuccessful (*Rep., Agric. Dept., Gold Coast*, 1913, p. 9). One of the palms introduced from the Cameroons has borne fruit in its fifth year, although the tree is in an exposed position on poor soil.

A comparison of the two methods of preparation of palm oil commonly used showed that by using unfermented fruit 14·3 per cent. of *soft* oil was obtained, while the fermentation method yielded about 18·5 per cent. of *hard* oil (*loc. cit.* p. 35) (cf. this BULLETIN, 1913, **11**, 212).

Oil mills have been erected in the Western Province, but no information as to the operations is available (*loc. cit.* p. 12). The quantities of oil and kernels exported in 1913 showed a considerable decrease; this appears to be due to low rainfall in 1912, and to the fact that larger profits can be obtained from cocoa cultivation. Large areas of oil palms are now neglected, and destruction of trees has been considerable in certain localities; a head chief of one district of the Eastern Province has submitted by-laws prohibiting the felling of oil palms.

The Oil Content of Seeds as Affected by the Nutrition of the Plant.—The results of a long series of researches on this subject are published by Garner, Allard, and Foubert in the *Journ. Agric. Res.* (1914, **3**, 227). The work was carried out at experiment stations of the U.S. Department of Agriculture principally with cotton seed, ground nuts, and soy beans, the latter being specially suited for such experiments, as they can be grown under widely different climatic conditions.

The experiments with soy beans showed that the increase of oil content of the seed is fairly uniform throughout its growth, except just after blooming and directly before maturity of the seed, there being a rapid increase in oil content in the seed in the few weeks after blooming, while there was a decrease in size of seed and in oil content during ripening; no evidence was obtained that a critical period of rapid accumulation of oil exists such as has been suggested by previous investigators.

Tests with cotton seed yielded similar results. For maximum oil production plants require conditions favouring the accumulation of carbohydrate during the vegetative period, and its transformation into oil during the reproductive period. Change in the normal distribution of vegetative and reproductive parts of the plant by removal of 50 to 60 per cent. of the leaves resulted in a reduction in yield of beans without any marked effect on their size or oil content in practically all cases; the removal of blossoms or young pods caused a distinct increase in the size of the remaining beans without any material effect on their oil content. No relationship appears to exist between oil content and size of seed.

Certain varieties of soy beans planted late in the season showed a marked tendency to shorten the period required to reach maturity; no relationship between date of planting and the size of bean or its oil content could be found—these properties appeared to be more influenced by the character of the season than by the time of growth. Soy beans of different varieties showed marked differences in size of bean and oil content when grown under the same conditions. Cotton showed decided differences in size of seed but little in oil content.

A large number of experiments were made on the influence of different types of soil on various oil seeds; the results on the whole pointed to the conclusion that the effects of different types of soil are not specific or constant, but depend largely on seasonal conditions. Under practical conditions climate rather than soil is the factor controlling oil content and size of seed, probably because climate largely controls soil conditions such as temperature and amount of moisture. Within ordinary limits the relative fertility of the soil appears to have only a small

influence on oil seeds; the use of a complete manure on an unproductive soil gave larger seed with a higher percentage of oil. The application of nitrogenous manures to cotton in increasing quantities had no effect on the size of seed, but lowered the oil content; phosphoric acid and potash had no effect. With soy beans phosphoric acid increased the oil content without altering the size of seed, while potash had no effect. With ground nuts no effect was produced by potash or phosphoric acid.

Essential Oils

Peppermint Oil.—In the *Perf. and Ess. Oil Record* (1915, **6**, 4) an account is given of a sample of peppermint oil distilled from Mitcham plants grown at Molo, in the highlands of the East Africa Protectorate. The oil possessed an excellent aroma, and had a specific gravity 0·967, and an optical rotation $-33° 30'$; it contained a large proportion of menthol, the alcohols (calculated as menthol) amounting to 67·5 per cent. It is considered that the East Africa Protectorate may become an important source of supply of this product.

Vetiver Oil.—A study has been made in India of the yield of oil from various samples of the roots of the vetiver plant (*Vetiveria zizanoides*, Stapf = *Andropogon muricatus*, Retz.), which is known locally as cus-cus or khas-khas grass. The results are published in the *Ann. Rep., Bd. of Scientific Advice for India*, 1913–14. The samples were collected in different parts of India, and at different seasons, and, on steam distillation, gave yields of oil varying from 0·37 to 1·14 per cent. It is considered that the amount of oil obtained from roots of average good quality may vary between 0·7 and 1·0 per cent., a yield of less than 0·7 per cent. indicating that the roots are of inferior quality. The quality depends mainly on the season at which the roots are collected, other factors, such as soil and locality, being of minor importance. The results of the work indicate that the roots should be collected towards the end of the winter and until the commencement of the rainy season.

Rubber

Hevea.—Hevea trees at the Aburi experimental station were tapped throughout 1913 on alternate days (excluding Sundays) over one-third of the circumference (*Rep., Agric. Dept., Gold Coast*, 1913, p. 34). Fifteen trees on plot 2 of an average girth of 35·8 in., tapped on the vertical paring system, yielded at the rate of 2 lb. 8 oz. of dry rubber per tree; on plot 3 the trees, which had an average girth of 33·3 in., were tapped on the half-spiral system, the average yield being 1 lb. 11½ oz. per tree. The yield from plot 2

was slightly less than that obtained in 1912, while that from plot 3 was $17\frac{1}{2}$ oz. per tree less than in 1912. At first thirteen trees on plot 3 were tapped, from June only twelve trees were tapped, and in December one tree failed to give any latex; several trees gave very low yields during the drier months.

In connection with the possible shortage of acetic acid in Ceylon, and the possibility of using other coagulants locally obtainable (see this BULLETIN, 1915, **13**, 158) Campbell states (*Planting Gazette*, 1914, **2**, 632) that the use of fermented coconut milk is only possible in certain localities owing to transport difficulties, while crude pyroligneous acid distilled from coconut shells is unsuitable for use in the preparation of pale rubber, and its use should be confined to the preparation of smoked rubber. Toddy vinegar can only be regarded as an emergency coagulant owing to its high cost.

Root disease of Hevea trees caused by a fungoid pest, *Sphaerostilbe repens*, first discovered in Ceylon by Petch in 1907, has now been observed in certain localities of the Federated Malay States (*Agric. Bulletin, F.M.S.*, 1914, **3**, 40). The fungus attacks both the bark and wood of the roots, but the strands of mycelium do not spread through the soil like those of *Fomes semitostus*. Although pure cultures of the fungus were obtained easily on sterilised blocks of Hevea wood, inoculation experiments on the roots of living Hevea plants, both on uninjured and injured roots, were unsuccessful, and the means by which the disease invades the roots is, therefore, uncertain; possibly some particular condition of soil, such as poor aëration, causes susceptibility to attack. The progress of the disease is slow, and is unfortunately not apparent until the foliage becomes thin and branches begin to die back. Affected trees should be cut down and burned, and lime should be applied liberally to the soil before planting on the infected area.

Canker, caused by *Phytophthora Faberi*, was less prevalent in Ceylon during the first half of 1913 than in the latter part of that year. The disease is characterised by a dark brown ring on the leaf stalk and falling of the leaves, often after fruit disease. Treatment of trees with "carbolineum plantarum" is recommended, as this has proved effective in Java (*Rep. Dept. Agric., Ceylon*, 1912–1913, p. 7).

"Pink disease" (*Corticium javanicum*), already referred to in this BULLETIN (1915, **13**, 157), is described fully by Brooks and Sharples in *Bulletin* No. 21, *F.M.S. Dept. Agric.*, which contains details of the author's scientific investigations, together with the methods recommended for combating the disease; numerous illustrations and a useful bibliography are included.

Two species of *Loranthus*, semi-parasitic flowering plants similar in their mode of life to common mistletoe,

have been found on Hevea trees in several localities in the Federated Malay States (*Agric. Bulletin F.M.S.*, 1914, **3**, 7). If these are allowed to develop to any large extent they will certainly cause damage to trees; all branches attacked by growths of *Loranthus* should be cut back well beyond the point to which the external creeping stems of the parasite extend.

Funtumia.—Further tapping experiments have been made in the Gold Coast on Funtumia trees previously tapped in 1911; 280 trees were tapped on the herring-bone system to a height of 100 in. The total yield was 24 lb. of dry rubber, different plots yielding from 0·64 oz. to 1·21 oz. per tree with an average of 0·9 oz. (*Rep.*, *Agric. Dept.*, *Gold Coast*, 1913, p. 34).

In an article by Lamborn dealing with the agricultural pests of the Southern Provinces, Nigeria (*Bull. Entomol. Res.*, 1914, **5**, 212) the following pests of *Funtumia* are mentioned. The larvæ of two moths, viz. a species of *Nephele* and *Glyphodes ocellata*, Hmp., attack the leaves, the latter especially on young plants. Funtumia pods contained many insect pests; the larvæ of *Entephria sexpunctatis*, Hmp., attack the seeds, as also do the small beetles *Berginus tamaricis*, Woll. The larvæ of *Arocatus continctus*, Dist., also feed on the seed, while the imago of the same species is found in large numbers under the leaves.

Balata.—Both in British and Dutch Guiana the depression in trade caused by the war has had a marked effect on the balata industry (*India Rubber World*, 1915, **51**, 233, 297). In Dutch Guiana, which produces about one quarter of the world's supply, over 200 tons of balata are awaiting transportation from the bush, but merchants do not care to incur the cost of transport. It is stated that the industry is likely to be ruined unless aid can be given to those interested.

Fibres

Paper-making Materials.—In *Bulletin* No. 72, 1914, *U.S. Dept. Agric.*, a report is given of an experimental study of the longleaf pine (*Pinus palustris*, Mill.) for the manufacture of paper pulp. The results indicate that the wood is well adapted for making natural-coloured "kraft" pulp and wrapping papers, and that the sulphate process gives a better product and higher yields than the soda process. The wood has a high specific gravity and consequently gives a larger yield of pulp per cord than is furnished by most other woods used commercially for pulp-making.

Silk.—Efforts are being made to improve the silk industry of Cyprus and place it on a firmer basis. An account of the activities of the Sericicultural Station at Nicosia in this

direction is given in the *Ann. Rep., Director of Agric., Cyprus*, 1913–14. Special attention has been given to the production of disease-free eggs for distribution to rearers, and demonstrations of the proper methods of sericiculture have been afforded to those engaged in the industry. The Department intends to establish other stations at which a few young men can be trained to act as travelling inspectors during the silkworm season. These inspectors will visit the rearers, advise them in their work, and see that the regulations are observed. The department is raising several thousand mulberry trees every year, and contemplates offering prizes to the cultivators for the best kept mulberry plantations. The methods of silk reeling at present practised are somewhat antiquated, and a small experimental silk-reeling plant is therefore being introduced with the object of effecting an improvement in this branch of the work. It is considered that silk-culture, if properly regulated, might become an important industry in the island.

An account of sericiculture in the Punjab is given in the *Year Book of the Punjab Agric. Dept.*, 1915. It is pointed out that the industry is only adapted to the sub-montane districts of the province where there is sufficient time for the development of the silkworms from the egg-stage to the cocoon-stage between the appearance of the mulberry foliage and the advent of the hot, dry winds of summer, and that it is particularly suitable for the small cultivator. A fresh supply of silkworm eggs is imported annually from France, and is distributed to the villagers and in the schools. An exhibition of cocoons was held at Amritsar and prizes were awarded to successful rearers. The largest rearings are carried out in the Gurdaspur district, where mulberry trees are very abundant. The Salvation Army also imports French seed and rears the worms at several of its settlements for criminal tribes; the reeling of the silk is also carried on at these settlements. Full instructions on the methods of rearing silkworms have been afforded by the issue of a departmental bulletin and a vernacular leaflet.

Cotton

West Africa.—An account of the experimental work on cotton in Southern Nigeria is given in the *Ann. Rep., Agric. Dept., Southern Nigeria*, 1913. Trials were made at the Ibadan Experiment Station with several American and native varieties. The latter were seriously attacked by the "leaf curl" disease. The results indicate that the Georgia variety would be the most profitable, as it gave an average yield of 139·8 lb. of lint per acre, of value £4 1*s.* 4*d.* Herbarium specimens of the varieties under cultivation were submitted to Kew for identification, and the native kinds were determined as follows: Meko,

Gossypium peruvianum, Cav.; Ishan, *G. vitifolium*, Lam.; Brazilian, *G. peruvianum*, Cav. Hybridisation experiments were carried out with the Ishan native and five American varieties with the object of obtaining a strain resistant to the "leaf curl" disease and possessing the American characters of increased productiveness, good grade of lint, and high percentage of lint to seed. The first year hybrids were satisfactory in all these respects, and seed was kept to be planted the following season. The hybrids proved to be practically immune to the "leaf curl" disease.

The *Rep., Agric. Dept., Gold Coast*, 1913, states that the cotton exports amounted to 27,497 lb., of value £688, as compared with 20,395 lb., of value £506, in 1912. In the Colony, cotton growing for export is confined to the Peki district, where the soil and climate are very favourable. As cocoa cultivation is a more profitable industry, however, the cultivation of cotton is left to the women and children, who grow it amongst the various food crops. In the Northern Territories the yields per acre are very low, and the prospects of a large industry are not promising. At the Tamale Experiment Station, an average yield of only 77 lb. per acre of seed-cotton was secured, and this is the best return obtained since the station was established.

India.—An account of progress in cotton growing in Bombay is given in the *Ann. Rep., Dept. Agric., Bombay Presidency*, 1913–14. In the Dharwar District, Cambodia, cotton is being recommended in preference to the Dharwar-American variety, the former giving a ginning percentage of 38 per cent. as compared with 28 per cent. for the latter. Cambodia cotton generally gives a larger yield per acre than Dharwar-American, but in 1912-13 the yield was poor owing to continuous rain just after sowing, and consequently the area devoted to it was reduced in 1913-14. In spite of this set-back, however, it is thought that its cultivation will become permanent, and that the demand for seed will increase. Considerable success has attended the introduction of Broach cotton into the western part of the Dharwar cotton tract; it gives a crop of seed-cotton at least as large as that of the local Kumpta cotton, and a ginning yield of 33 per cent. as against 27 per cent. in the case of the latter variety; in some villages it is now being grown almost to the exclusion of Kumpta cotton. Good results have also been obtained in the improvement of the Kumpta cotton, and a strain has been established by continuous selection which gives a ginning yield 3 or 4 per cent. greater than that of the ordinary kind. Improved strains have been introduced into cultivation in lower Gujerat, and 17,000 acres in the region of Surat have been planted with seed of these forms. In Khandesh, the cultivators have realised the advantage of the new "roseum" cotton over the

ordinary Khandesh mixture, and the demand for the seed has been greater than the supply available for distribution.

An account of the cottons of the Punjab and the efforts which have been made by the Agricultural Department to improve the crop is given in the *Year Book of the Punjab Agric. Dept.*, 1915. It is pointed out that the early attempts to produce a long-stapled cotton were somewhat premature, as it was not sufficiently recognised that in order that any particular variety should be profitable to grow it must give a good average yield per acre, a high percentage of lint, must be resistant to drought and disease, and must ripen early. A number of exotic varieties have been tested at Lyallpur Farm; the tree-cottons were late in maturing and did not yield a crop; the Egyptian varieties gave very poor results; African cottons and the Cambodia variety from Madras began to produce their bolls just before the commencement of the frosts. The only long-stapled cottons which have proved successful are American varieties. As the result of numerous selection experiments, the form known as 4F, produced from a single plant, has proved the most satisfactory; it gives good yields, is not particularly liable to attack by insect pests, but is a little late in maturing. About 2,000 acres were planted with this cotton in 1914, and large quantities of seed will be available in future. American cotton is grown largely in certain districts, but this is composed of a mixture of varieties, and a good deal of native cotton is mixed with it; consequently the lint is not uniform and cannot command good prices. It is hoped that this cotton will be replaced by the 4F kind. Work with the indigenous varieties has not proved so satisfactory, and no pure variety has yet been obtained from a single plant which is generally suitable and superior in quality or yield to the mixtures usually grown. An indigenous form of *Gossypium sanguineum*, Hassk., which gives good yields of a short, rough cotton, has been grown on a large scale at Lyallpur, and the seed distributed to cultivators. About 1,450 acres in the Lyallpur district were planted with this variety in 1914.

In the *Rep. Dept. Agric., Madras Presidency*, 1913–14, an account is given of progress made in the improvement of varieties by seed selection. The chief improvement effected hitherto in Tinnevelly has been by the distribution of pure Karunganni seed selected from bulk. During the year under review, however, a superior single-plant strain was grown on a large scale in the villages, and the resulting cotton was submitted to spinning trials. The yarn spun from cotton of the new strain was found to be stronger and more uniform and even than that spun from the cotton produced from seed from bulk selection. The ginning yield of the new cotton is nearly 28 per cent. as compared with 25 per cent. for the bulk selection cotton. An area of 300

acres was planted with seed of this strain, and arrangements were made to collect the seed-cotton and have it ginned separately; it was anticipated that in October 1914 about 7,000 acres would be devoted to this special form. Cambodia cotton is now thoroughly established, especially in the south of the Presidency. Complaints are received occasionally that the cotton is deteriorating, but this is considered to be due to the extension of the cultivation to dry lands, where the quality of the cotton produced is inferior to that grown on land provided with wells.

West Indies.—The cotton crop in St. Vincent was injured by rain during the harvesting season of 1913–14. In the *Rep. Agric. Dept., St. Vincent*, 1913–14, it is stated that the production amounted to 399,187 lb. of Sea Island cotton, and 58,737 lb. of the Marie Galante variety. The average value of the Sea Island cotton was estimated at 19*d.* per lb., and that of the Marie Galante variety at 10*d.* per lb. The area under cultivation was 3,768 acres, devoted to Sea Island, and 576 acres to Marie Galante cotton; in comparison with the previous year, these figures show a decrease of 576 acres in the case of the former, and an increase of 138 acres in the case of the latter variety. The yield per acre was 106 lb. of lint for Sea Island and 47 lb. per acre for Marie Galante. More attention was given to the cultivation of Sea Island cotton in the Southern Grenadines than in previous years, and promising results were obtained. Selection experiments have been continued with the object of obtaining strains of Sea Island cotton, resistant to disease, and yielding lint of desirable quality; special attention has been given to the diameter of the fibre with a view to obtaining cotton with a high degree of fineness.

It is stated in the *Rep. Bot. and Exp. Station, Tortola, Virgin Islands*, 1913–14, that the season was very unfavourable for cotton growing. A larger area was devoted to the crop than in the previous year, but owing to the small yields obtained only 32,317 lb. of lint, of value £2,191, were exported as compared with 36,383 lb., of value £2,446, in 1912–13. The average ginning yield was 25·6 per cent. The plants suffered greatly from attacks of the leaf-blister mite (*Eriophyes gossypii*), the infection being conveyed by old cotton bushes which had been left in the ground. The Agricultural Department has given considerable attention to this pest with a view to its extermination. Experiments were carried out at the Experiment Station to ascertain the best month for planting Sea Island cotton, and a system of seed selection was commenced with a view to obtaining good strains of cotton, particularly adapted to local conditions of soil and climate, and yielding lint of uniform quality.

According to the *Rep., Bot. Station and Exp. Plots, St.*

Kitts—Nevis, 1913–14, the areas devoted to cotton in the season under review were 2,000 acres in St. Kitts, 2,500 acres in Nevis, and 1,000 acres in Anguilla. In St. Kitts, 1,600 acres were planted as an intermediate crop with sugar-cane and 400 acres as a permanent crop. Unfavourable weather was experienced at the time of planting, and the average yield of lint per acre was only about 160 lb., which is less than that obtained in previous years. The quality, however, was very good, and prices of 1*s.* 8*d.* to 1*s.* 10½*d.* per lb. were realised for the greater part of the crop. Selection experiments with Sea Island cotton were continued with a view to maintaining the high quality of the plants with respect to both yield and quality of fibre. The results of the work were most encouraging and all the selected seed (3,176 lb.) was sold locally at 2½*d.* per lb. In Nevis, the weather conditions were unfavourable for the young plants, but the general return was better than that of the 1912–13 season, the average yield being about 120 lb. of lint per acre. The quality was also superior, and most of the cotton was sold at 18*d.*–19*d.* per lb. In Anguilla, the cotton season was fairly successful. The exports of cotton from the three islands up to the 30th June, 1914, were as follows: St. Kitts, 345,633 lb.; Nevis, 266,773 lb.; Anguilla, 94,372 lb., making a total of 706,778 lb.

Tobacco

In 1904 a scheme of large-scale experiments in the cultivation of tobacco was started by the Department of Agriculture and Technical Instruction for Ireland, the progress of which has been noted occasionally in this Bulletin (1911, **9**, 173, 416). This scheme was concluded with the crop of 1913, and a new one, covering a period of ten years and financed out of the Development Fund, was inaugurated in 1914 (*Journ. Bd. of Agric. and Tech. Instr., Ireland*, 1915, **15**, 527). The special object of this new scheme is to provide efficient means for preparing the tobacco for market. The tobacco grown and cured by the farmers will be purchased by three "re-handlers," who will grade, sweat, re-dry, pack, mature, and market the product. The scheme provides that in the case of two of the re-handlers an area not exceeding 114 acres in any year is to be cropped, of which at least three-fourths shall be on the land of working farmers; in the third case the total area is not to exceed 25 acres. The re-handler is to provide the growers with all necessary instruction and equipment, and provided certain prescribed conditions are complied with, will receive a grant of £25 per acre cropped. In 1914 the number of growers and the total areas cropped in the different centres were 137 and 218 acres respectively. The season was a dry one, and the harvest was delayed, but on the whole

the results were regarded as satisfactory. On all but 6½ acres pipe tobaccos were grown, of which "Copper King" proved the most suitable, although "Kentucky Black" gave particularly good results in one field. Cigarette tobacco of the Virginia type was produced with comparative ease and economy at one centre on an area of 4½ acres planted with the "Irish Gold" variety. One acre was devoted to each of the "Samos" and "Giourkioi" varieties of "Turkish" cigarette tobacco, but the results were less successful than in previous years.

According to the Annual Report on Weihaiwei for 1913 (*Colonial Reports, Ann. Ser.*, No. 804 [Cd. 7050-45] p. 7) experiments on the cultivation of tobacco are being made in that territory. Trials are being made with a number of varieties and seed has also been distributed among Chinese farmers. The soil and climate are regarded as well suited to the crop, and it is stated that there seems every hope that the experiments will succeed.

The cause of the mosaic disease of tobacco has been the subject of much discussion. Microscopic examination has failed to detect the presence of a parasitic organism, and the suggestion has been made that the disease develops when certain oxidising enzymes normally present in the plant increase in amount or in activity as a result of various external conditions affecting nutrition and growth. An interesting experiment bearing on the subject has been conducted by H. A. Allard (*Journ. Agric. Res.*, 1915, **3**, 295). A quantity of expressed sap from mosaic-diseased leaves was filtered and diluted to various degrees with tap water. It was found that when the leaves of a young, healthy plant were inoculated by introducing, by means of a needle, minute quantities of a solution containing one part of the sap to 1,000 parts of water, the disease developed as readily as when the undiluted sap was used. A solution of one part in 10,000 also induced the disease, but to a less extent. The author concludes from these results that there must be something in the virus quite extraneous to the protoplasmic constitution of healthy plants, and that the theory of a parasitic origin of the disease more consistently accounts for all the facts than any enzymic conception yet evolved.

FORESTRY AND FOREST PRODUCTS

Forestry in Australia.—In proportion to the total land surface Australia has an extremely small area of timber forest. The area has been estimated at over 100,000,000 acres, or about 5 per cent. of the total land surface, but H. R. Mackay, Conservator of Forests, Victoria, in an article in the *Journ. Dept. Agric., Victoria* (1915, **13**, 169), points out that such estimates do not distinguish between

true forest land, bearing timber of commercial value, and other large areas irregularly wooded or bearing dwarf and stunted trees. From an examination of all available authorities he considers that the true forest area is less than 4 per cent. of the total land area, as compared with 52·2 per cent. in the case of Sweden, 43 per cent. in Russia, 33·6 per cent. in the United States, and 22·3 per cent. in Canada. The forests are chiefly coastal, there is no great wooded territory in reserve in the central plains and plateaux, and as settlement proceeded from the fertile lands of the plains to the mountain ranges vast areas of valuable timber land were deforested, with the result that after only about seventy years the Australian forests, in the opinion of the author, have been brought to a condition of partial ruin. It is his opinion that all the States have for many years neglected the simple elements of proper management and control, and that the safe timber yield of the reserves has been overtaxed in order to foster an extravagantly wasteful export trade. In nearly every State there are extensive areas of waste land on which spruce and pine could be grown to supply the local demand for soft wood for building construction, practically all of which at present has to be imported. So far, however, very little has been done in this direction.

The author gives a useful summary of the extent and composition of the forests in each State, and pays particular attention to the mountain water-sheds of Victoria.

Timbers

Cornus Wood.—An account of the uses of the timber of various species of *Cornus* is given by W. Dallimore in *Kew Bulletin* (1915, p. 179). It is pointed out that the branches of most of the species are tough, and when split longitudinally are used for hoops of barrels, but those species that form distinct trunks have the greatest economic value, and the timbers of some of them are in regular demand. That of *C. florida*, Linn., a native of Eastern North America, resembles boxwood, and is sometimes used for wood-engraving. Its chief use, however, is for turnery, and it is employed for shuttles, spindles, cotton-reels, tool handles, cogs and hubs of wheels, etc. The wood of *C. Mas*, Linn., the cornelian cherry or cornel, which occurs wild throughout the greater part of Europe, and in certain parts of Western Asia, is used for hayforks, walking sticks, staves for ladders, tool handles, etc., but as it is hard and close-grained it could also be used for turnery. *C. Nuttallii*, Aud., a species native to the coastal region of North America from British Columbia to South California, also yields a hard, fine-grained wood, which is used for turnery, tool handles, mallets, cabinet-making, and other purposes.

The wood of *C. sanguinea*, Linn., the common dogwood of Europe and North and West Asia, is close-grained and yellowish, bearing a striking resemblance to boxwood. It is not in regular use, although it has been used for similar purposes to that of *C. Mas*. *C. macrophylla*, Wall., which inhabits the forests of the Himalayas, China, Corea, and Japan, is one of the largest species of *Cornus*, and is frequently found 40–60 ft. high with a trunk upwards of 12 in. in diameter. The wood has been used for cabinet work and turnery. *C. Kousa*, Buerger, a native of Central China and Japan, also possesses a trunk, but little is known as to its value as a timber tree. The wood is not unlike that of *C. florida*, and it could probably be used for turnery. Most of the species mentioned are stated to be employed as a source of gunpowder charcoal.

Tanning Materials

Mangrove Bark.—With reference to the shortage of tanning extracts in the United Kingdom, the Commissioner of Trade and Customs at Kuala Lumpur, F.M.S., states that the attention of manufacturers might be drawn to the possibilities of trade in mangrove extract from the Federated Malay States (*Bd. of Trade Journ.*, 1915, **88**, 377). There is an area of about 250 square miles of mangrove forest on the coast of the States of Perak and Selangor, and a list is given of six predominant species. The whole forest is now a Government reserve, and is systematically worked for firewood. No attempt has yet been made to work the mangrove bark for extract. All the bark is at present a waste product, with the exception of a small quantity used locally for treating fishing nets and sails. The forests are intersected with numerous creeks and streams, which render transport easy.

Myrabolans.—A table is given in the *Indian Forester* (1915, **41**, 17), showing the results of tannin estimation of thirty-five samples of myrabolans from Madras and Balaghat. It is recommended that the myrabolans should not be allowed to remain too long on the tree, but should be picked as soon as they are fully ripe.

Miscellaneous.—A description by the Superintendent of Forests, Marwar, of the occurrence in Marwar of *Cassia auriculata*, Linn., is quoted in the *Indian Forester* (1915, **41**, 14). The species grows locally as a gregarious shrub, over a belt of ten to thirty miles at the western foot of the Aravallis Hill range of Rajputana, in the south and south-west corner of Marwar State. The shrub does not grow well in reserved forests, or in any well wooded area, but generally occurs along the river courses, or in low lands and around cultivated areas. The bark is stated to be preferred locally

for tanning purposes to babul bark and bhunbaoli root bark (*Acacia Jacquemontii*, Benth.), both of which are available in large quantities. The annual export of *Cassia auriculata* bark, known locally as "Tarwar," to the Sindh and Bombay markets, is roughly estimated to vary from 3,000 to 19,000 cwts., and the consumption in Marwar is estimated at 19,000 cwts. The bark is sold at an average price of 4*s.* 6*d.* per cwt., delivered at the nearest railway station.

The results are given of the examination of three samples of bark, from which it is concluded that bark grown for one full year should be considered sufficiently mature for exploitation, so far as its tannin percentage is concerned. (See also *Technical Reports and Scientific Papers of the Imperial Institute*, 1903, Part I., pp. 184, 185.)

Gums and Resins

Copal.—According to a report from the American Vice-Consul at Boma, quoted in the *Indian Tr. Journ.* (1915, **36**, 265), a large native market for copal has been created at Basankusu, Congo, to which 585,596 lb. were brought during 1913—344,060 lb. in the fourth quarter of the year alone. It is stated that the natives are taking an increased interest in the gathering of copal, and prefer to bring their products to the native market, rather than to sell them to the itinerant agents of traders.

Lac.—It is understood that in consequence of certain trade difficulties caused by the war, Nagod and Maihar, two of the lac-producing States of Central India, have decided to open a factory to assist their forest tribes, who are feeling the temporary cessation of the lac and hide trades (*Indian Tr. Journ.*, 1914, **35**, 440). The factory will form a collecting and distributing centre for the jungle produce of these States, and is situated at Maihar on the East Indian Railway.

Pine Resin.—According to the *Progress Report of Forest Administration in the Punjab*, 1913–14, p. 12, the site of the turpentine factory at Shahdara was inundated, shortly after the close of the year under report, by a heavy flood in the Ravi, which caused so much damage that it has been decided to abandon the factory and to erect a new one at Sallo Railway Station, about nine miles east of Lahore. New plant was purchased during the year capable of dealing with 30,000 cwts. of crude oleo-resin per annum, which is estimated to be at present the maximum annual output of the Punjab forests. During the eight months in which the Shahdara distillery was at work, 5,600 cwts. of crude oleo-resin were treated, yielding 8,525 gallons of turpentine oil and 3,303 cwts. of rosin (colophony), as compared with 12,941 gallons of turpentine oil and 5,515 cwts. of rosin obtained

during 1912–13 from the treatment of 7,500 cwts. of crude oleo-resin. The average prices obtained for turpentine oil and rosin were 2*s.* 6*d.* per gallon and 13*s.* 2*d.* per cwt. respectively. Tapping operations were confined to the Rawalpindi and Kangra Divisions, and resulted in a yield of 11,358 cwts. of oleo-resin during 1913 as compared with 8,437 cwts. obtained in 1912. It is stated that a larger output than this could have been obtained, but operations were restricted during the latter half of the year, as there was already a large stock of crude oleo-resin in hand with which the existing plant was incapable of dealing.

Forest Bulletin No. 26, 1914, entitled "The Resin Industry in Kumaon," gives an account of the development of the turpentine industry in the Kumaon district. Tapping operations were started on a small scale in the Naini Tal Forest Division in 1896 with 10,000 trees, and a distillery was erected at Bhowali. Operations have been extended, until in 1913–14 670,000 trees were tapped, giving a yield of 32,000 cwts. of crude oleo-resin. The method adopted is to work a forest for five years, then to give it a ten years' rest, and again work it for five years, and so on. It is found that this does no harm to the standing trees or to the forest. A description is given of the method of tapping and collecting the crude oleo-resin, its distillation, the rectification of the turpentine oil, etc. At the present time about twenty-five different forests are being worked for the supply of oleo-resin to the Bhowali distillery, and it is anticipated that in three years' time this distillery will be able to supply about 60 per cent. of the total consumption of turpentine oil and 80 per cent. of the rosin consumption of India. Another distillery will shortly be erected near Tanakpur in Eastern Kumaon, from which an approximate annual output of 25,000 gallons of turpentine oil is expected.

ECONOMIC MINERALS

Chromite.—In *Trans. Geol. Soc., South Africa* (1914, **17**, 60) A. E. V. Zealley deals with the geology of the chromite deposits of Selukwe, Rhodesia. The chromite of Selukwe occurs in a mass that consists predominantly of talc schist and serpentine. This has been invaded by a large intrusion of granite which is ten miles long and four miles wide. The rock of the talc schist and serpentine mass was originally peridotite, containing chromite as a product of igneous segregation. The peridotite has been metamorphosed, the chief products of metamorphism being talc, dolomite, serpentine, and chlorite. Chromite is an important constituent, and some magnetite is also present.

Chromite occurs in all the rocks of the talc-schist group, but it is in the talc schist itself that the large bodies of chromite occur, in the form of lenticular masses. About 130

of these masses were mapped at the surface, and most of these were of a size ranging from 150 to 450 ft. in length. Smaller masses are very numerous. Eight or ten of the most important of the larger bodies are being worked at the Chrome Mine, and during the period of about nine years that this mine has been worked, more than 300,000 tons of ore has been obtained and exported in a crude state to Europe and America.

The chromite shows a variable composition. The average high-grade ore is stated to contain about 50 per cent. of chromic oxide (Cr_2O_3), but the percentage falls as low as 35 in some of the solid masses of chromite that have been sampled. Analyses of seven samples representing ore as sold, show variations in chromic oxide percentages from 41·7 to 51·2. As usual in commercial samples of chromite there are fairly large percentages of magnesia and alumina due to admixture with spinel. The percentages of magnesia and alumina in the seven analyses above referred to ranged from 8·3 to 15·15 and 14·5 to 16·44 respectively.

It is of interest to note the evidence given as to variability of composition within the limits of a given mass. An instance is quoted of a small oval body about 30 × 30 ft. in size, from which about 2,200 tons of ore was obtained, in which it was found that the marginal offshoots of the mass contained considerably less than 50 per cent. of chromic oxide, whereas the main mass contained more than 50 per cent. Another observation of some interest is the occurrence of an outer shell of "close-grained massive chromite" around an inner and more coarse-grained material in some of the chromite lenticles. Lastly, it is noteworthy that though the trend of the chromite lenticles frequently coincides with the strike of the foliation of the enclosing talc schist, this is not invariably the case. The chromite bodies lie in all positions in the schistose matrix; and they do not usually exhibit any foliation in themselves.

Clay.—In *Bulletin Amer. Inst. Min. Eng.* (1915, Feb., p. 301), N. B. Davis contributes a paper on the plasticity of clay in relation to its mode of origin. He contends that the fresh powders obtained by crushing crystalline rocks do not exhibit plasticity when wetted, though they may develop plasticity if ground in water for a long time. This plasticity, which is also developed by the long-continued action of weathering agencies on surface rocks and their disintegration products, is due to the formation of colloids resulting from solution action on the grains. The colloids thus formed include hydrated silica, alumina, iron oxides, silicates, and organic compounds. They may coat the grains or replace the grains completely as products of alteration. Two or more of these hydrated compounds are usually present;

their effect is modified by the adsorbed salts, and the relative proportion of large and small grains. The amount of colloidal matter present depends upon the history of the rock. "Clays are simply the weathering products of crystalline rocks in which the most soluble constituents have been removed, leaving behind more resistant secondary products (crystalline and amorphous) with gelatinous coatings. The most highly plastic clays are those that have been subjected to the action of water for long periods. Residual kaolins are of low plasticity, but water-transported kaolins of exactly the same chemical composition are very plastic."

Coal.—In *Rec. Geol. Surv. India* (1914, **44**, 163), G. de P. Cotter, of the Geological Survey of India, describes some newly discovered coal-seams of Eocene age near the Yaw river, Pakokku District, Upper Burma. Numerous sections, as seen in excavations, are described. In one of these, near Letpanhla, there is a thickness of nearly 13 ft. of coal in a total thickness of some 28 ft. of strata, but there are numerous partings of clay and shale. One seam of coal in this section is 3½ ft. thick and another 2 ft. The general dip in this Letpanhla area varies from about 30° in the south to about 40° near the Yaw river. The main seam is 6 ft. thick for a distance of about half a mile, and 5 ft. thick for a distance of about a mile, along the outcrop.

Analysis of twenty-two samples of the coal show compositions varying between the following limits:

	Per cent.
Fixed carbon	29·32–39·26
Volatile matter	31·74–37·36
Moisture	15·63–21·60
Ash	7·28–21·68

The total sulphur in eight samples varied from about 2·1 to 5·6 per cent., and the calorific value of the same eight samples ranged from about 4,500 to 4,835 small calories. The coal cracks on exposure to the air, and from the description given it appears to be of the brown coal variety. This fact, together with the high sulphur percentage, the comparatively low calorific value, and the remoteness of the locality from means of transport, renders the coal of no economic importance at present.

Gold.—According to the Annual Report of the Commonwealth Government on Papua for the year 1913–14, the estimated total output of gold for the year ended June 30, 1914, was 14,666 oz., valued at £50,110, a decrease of 3,581 oz., as compared with the previous year. During the year a good deal of interest was taken in dredging. Suitable areas for dredging are believed to exist on the Mambare, Gira, and Lakekamu rivers. Twenty-one dredging claims are now held, and others have been applied for.

The total gold production of the Federated Malay States for 1914, as reported to the Secretary of State for the Colonies, was 14,272 oz., valued at £55,306. This represents a decrease of 653 oz., as compared with 1913, in which year the total output was 14,925 oz., valued at £57,834. The total output for 1913, previously given in this BULLETIN (1914, **12**, 322), included 50 oz. now stated to have been exported prior to 1913.

Monazite.—In *Rec. Geol. Surv. India* (1914, **44**, 186) Mr. Tipper, of the Geological Survey of India, gives an account of the monazite sands of Travancore. He refers to five localities on the Travancore coast south of Quilon where monazite occurs abundantly. These are Nindikarai (Quilon), Anjengo-Warkalli, Kovilam, Muttum-Purdur, and Cape Comorin-Liparum. Intervening between these localities there are long stretches of barren sand with only traces of monazite.

Mr. Tipper records the occurrence of monazite in the pegmatite intrusions that traverse the gneisses. An analysis of a specimen of monazite from these pegmatites showed 6 per cent. of thoria. Favouring the supposition that monazite occurred in the gneisses as well as in the pegmatites, and that the monazite of the beach sands and sand dunes had been derived primarily from the disintegration of these rocks, he examined the gneisses for monazite, but could not find any, either in the slides or in the concentrates prepared from the gneisses he examined.

On this point, however, mention should be made of the results obtained by previous workers, notably the observations made by Messrs. Masillamani and Chacko, State Geologists of Travancore. In their report on work carried out between the years 1907–1910, both these geologists record the occurrence of monazite, not only in the pegmatites, but also as an accessory constituent of garnetiferous biotite gneiss (see this BULLETIN, 1913, **11**, 699). Mr. Masillamani reports it in biotite garnet gneiss "on the eastern side of the road leading to Oliver's Estate from the main Nagercoil-Balamore road." Mr. Chacko reports it in a specimen of garnet gneiss from an exposure in a gully at Kanjirode. A microscopical examination of sections of this rock showed monazite in rounded grains intimately associated with garnet and ilmenite.

In this connection it is also worthy of note that monazite is found in a garnetiferous biotite gneiss near Nugatenna Gap in the Central Province, Ceylon (*Colonial Reports—Miscell.*, No. 42, *Ceylon* [Cd. 3762], 1907, pp. 10 and 39).

According to Mr. Tipper, "it seems natural to conclude that monazite is most likely to occur in those parts of India where charnockites are well developed." According to Mr. Chacko, however, "the Kallada is the northernmost river in which monazite can be found to any appreciable

extent. The geological peculiarity of the Kallada and the more southern rivers is that they flow mostly over garnetiferous gneisses, whereas the northern rivers flow over charnockite."

It will be interesting to see whether one or other or both of these views receive confirmation by future geological work; but as the evidence stands it appears probable that, apart from its occurrence in the pegmatites, monazite occurs disseminated in the ordinary gneisses rather than in the rocks of the charnockite group.

Monazite is now known to occur in many parts of India. Hitherto, however, no deposits comparable in richness to those of the Travancore beach sands have been found. Monazite is stated to occur widely in the Tinnevelly district, where it is found in stream deposits and in older dunes; but it seems unlikely that deposits of workable value will be found in the Tinnevelly area.

Monazite has also been found in sands from Gwalior examined at the Imperial Institute. One sample of a concentrate from this State was found to contain about 10 per cent. of the mineral. The mineral is also reported to occur sparingly in concentrates from other areas in India.

Petroleum.—In a paper entitled "Notes on the Development of the Trinidad Oilfields" (*Journ. Inst. Petrol. Tech.*, 1915, **1**, 99) J. Cadman gives a brief summary of information on this subject, and deals with some of the difficulties that have been encountered in the work of prospecting the Trinidad oilfields.

The Tertiary beds in which the oil occurs have an estimated thickness of from 6,000 to 6,500 ft. They consist chiefly of clays, sands, and marls, and the oil-bearing rocks are confined mainly to three horizons. The upper horizon is that of the La Brea sands, which outcrop at La Brea and form the famous Pitch Lake of Trinidad. The middle horizon is that of the Rio Blanco Oilsand, some 1,400 to 1,500 ft. deeper, and the lower horizon, at a further depth of 3,600 to 4,000 ft., near the base of the Tertiary beds, is known as the Galeota horizon.

The oils obtained hitherto vary widely in composition. At the upper horizons the oil is heavy, having an asphaltic base, a specific gravity rising as high as 0·975, and a percentage of petroleum spirit as low as 4. At the lower horizons the oil is lighter, the specific gravity falling to 0·810, and the petroleum spirit rising to 40 per cent.

One of the chief difficulties met with in developing the Trinidad oilfields is the frequency of loose sands and clays, which, when associated with great gas pressure, as in the south of Trinidad, give rise to natural gas eruptions and mud volcanoes. These loose sands and muds present serious obstacles in drilling operations, and lead to the

frequent choking of wells. Moreover, as much as 30 per cent. of sand may be present in the oil that issues from a well during the flow of the first few days. Subsequent to this there may be 10 to 15 per cent. of sand in the outflow for two to four months, after which the outflow is comparatively free from sand. With oil carrying 10 per cent. of sand, settlement in an open sump is accompanied by a loss of from 2 to 3½ per cent. of volatile oil from the original volume, by evaporation through exposure to the tropical sun. The problem of separating the sand from the oil under these conditions without loss has not yet been solved.

The following table shows the growth in output of Trinidad petroleum in relation to feet drilled and number of wells from 1908 to 1914:

Year.	Output in Imperial gallons.	Feet drilled.	No. of wells.
1908	5,900	3,758	4
1909	2,000,000	5,927	6
1910	5,000,000	7,321	7
1911	9,985,740	14,485	14
1912	15,288,162	40,418	46
1913	17,626,563	42,552	44
1914	22,523,660	41,933	41
Total	72,430,025	167,044	174

Thorianite.—In *Bull. Soc. Min. France* (1914, **37**, 176) M. A. Lacroix reports the occurrence of thorianite in the Ambatomainty region in the south of the province of Betroka, south-eastern Madagascar. It is of interest to note that large zircons with low density and anomalous optical characters, of the type common in Ceylon gem gravels, have already been recorded from this district.

The thorianite occurs in good crystals. The exact locality is apparently not yet known, and the conditions of occurrence remain to be studied; but there can scarcely be any doubt that its mode of occurrence and associated minerals will prove to be closely similar to those found in Ceylon.

A fragment of a large cube was found to be brownish-black in mass, brownish in thin sections, and isotropic. The mineral has a specific gravity 9·33, a hardness 6½, and is highly radioactive. It is infusible in the blowpipe flame, and is decomposed by strong nitric acid. A preliminary analysis by M. Pisani gave:

		Per cent.
Thoria	ThO_2	93·02
Uranium oxide	UO_2	4·73
Ferric oxide	Fe_2O_3	0·29
Lead oxide	PbO	1·80

This analysis shows a much higher percentage of thoria than that of Ceylon thorianite. With reference to its rarity, M. Lacroix describes thorianite as a mineral "qui n'était connu jusqu'ici qu'à Ceylan." In this connection, however, reference should be made to the recorded occurrence of thorianite from a gold-placer deposit on the river Boshagoch in the Transbaikal province of Asiatic Russia, where thorianite occurs in small black cubes having a composition closely similar to that of the Ceylon mineral (see this BULLETIN, 1912, **10**, 514).

NOTICES OF RECENT LITERATURE

A HISTORICAL GEOGRAPHY OF THE BRITISH DOMINIONS. Vol. IV.: SOUTH AFRICA. Part II.: HISTORY TO THE UNION OF SOUTH AFRICA. By Sir Charles Lucas, K.C.B., K.C.M.G. Pp. viii + 533, Crown 8vo. (Oxford: At the Clarendon Press, 1915.) Price *6s. 6d.*; post free, United Kingdom *6s. 10d.*, abroad *7s. 2d.*

This latest addition to an admirable series shows Sir Charles Lucas at his best. The book is extremely clear, it misses nothing, yet, for all its compression, it is most readable. It covers the period from 1895 down to the formation of the Union. That over half of it should be taken up with a history of the South African War was, of course, inevitable. Incidentally, those who want a concise history of that struggle will find the book worth buying on that account alone.

Sir Charles Lucas's judgments on the results to the Empire of the South African War are particularly sane. He points out that it was fought for, and resulted in, equality of the white races, and it made—where nothing else could have made—Union possible. Moreover, the self-governing Dominions had no small hand in it, while its outcome was a self-governing Dominion.

Apart from the great merits of this volume as a compilation of essential facts, its broad Imperial outlook would alone make it memorable. In particular the author urges the great moral of the South African War—that the overseas policy of Great Britain should be consistent and unswerving.

In a series of appendices are given the terms of the Pretoria Convention of 1881, the London Convention of 1884, the Middelburg terms offered by Lord Kitchener to General Botha in 1902, and the Vereeniging treaty of the same year. There are an excellent index, several maps specially drawn by Mr. B. V. Darbishire, and a list of standard works on South Africa.

JAVA ET SES HABITANTS. By J. Chailley-Bert; 4th ed. Pp. cxlvii + 330, Crown 8vo. (Paris: Armand Colin, 1914.) Price 5 francs; post free, United Kingdom 4*s.* 4*d.*, abroad 4*s.* 5*d.*

This book was first published in 1900, and has, needless to say, been accepted as authoritative on its subject. But, as M. Chailley-Bert now explains, Dutch political plans and administrative views have during the last fifteen years been modified by events. Certain reforms have been introduced in this period; others, of even more importance, are being considered. The first fact made some addition to the original work necessary, though in its main lines there has been no alteration. On the other hand, the time has not yet come for an entirely new volume.

The essential change in Holland's East Indian policy of recent years is the adoption of what may be called an All-Indies instead of a purely Java policy. Holland, like the United Kingdom, has been forced into a wider exercise of authority in the East. Java, though remaining, of course, her special pride, is no longer allowed to monopolise her attention. She has at last taken steps to establish her authority in her Outer Possessions—Sumatra, Timor, New Guinea, and a permanent department for the management of all questions concerned with the Outer Possessions has been established in Batavia. Hitherto the government of these Outer Possessions had been merely rudimentary; their resources had not been explored, much less exploited.

Amongst the reforms of the last fifteen years, the first was the creation in Java—in 1904—of a Ministry of Agriculture. The object of the Department, as eloquently put by M. Chailley-Bert, is "to discover and promote the true methods which utilise, preserve, protect, and develop the agricultural enterprises and resources of the country, and thus contribute to its support, enrichment, or public honour." The 1913 budget for this Department amounted to 10,820,000 florins. The Department directs the Government's agricultural undertakings (consisting of gutta-percha, rubber, coffee, and cinchona plantations), carries on the forestry service and civil veterinary service, and manages the famous Garden and Institute of Tropical Agriculture established nearly a century ago at Buitenzorg. M. Chailley-Bert gives a most interesting and detailed account of this establishment, as well as of the sub-department dealing with natural applied sciences, which was founded on lines similar to those existing in certain British Colonies.

A second agricultural reform has been to place the lessons of agricultural science at the service of the Dutch at home and in the East, and also of Europe generally, by means of public laboratories, agricultural schools, and widely-circulated literature. There are already several agricultural schools in Java, and more are being created

from time to time. The competition to enter these schools is great, the number of candidates always exceeding the number of vacancies. Entrance is now dependent on the results of an examination.

Another way in which the Dutch Government has of recent years given assistance to agriculture is by the purchase of some of the large estates in Java from private owners who were only partially utilising the resources of their property.

The new material in the present edition covers 147 pages. As it is all printed together in the form of an introduction instead of being dispersed throughout the book, it can be assimilated without loss of time by those who are familiar with the earlier editions, but wish to have the latest information on the subject in compact form. Those who are not familiar with the original volume would do best to read this new section last, for it is really more of a supplement than an introduction. The book (and, above all, that part of it which shows what the Dutch Government is doing for the agricultural resources of the Dutch Indies) may be specially commended to the attention of all who are interested in the welfare of our own tropical Empire.

Lands Forlorn. By George M. Douglas. With an introduction by James Douglas, LL.D. Illustrated. Pp. xv + 285, Small 4to. (New York and London: G. P. Putnam's Sons, The Knickerbocker Press, 1914.) Price $4 net; post free, United Kingdom 17*s.* 1*d.*, abroad 17*s.* 8*d.*

This is the narrative of a joint expedition by a Canadian engineer, a Swedish scientist, and a Canadian naval officer to Hearne's Coppermine river, which passes into the Arctic Ocean from the so-called Barren Lands of the North-West Territories of Canada in Latitude 68° 49′ N. and Longitude 115° 32′ W. The ostensible object of the expedition was to obtain material for a report on the copper-bearing rocks of Hearne's Coppermine river, but it is doing the author (who was the leader of the expedition) no injustice to surmise that the love of exploration for its own sake had a far more important influence on the journey.

The earliest investigations of this remote territory were prompted by the Indian tales of great copper deposits in the mountains of the far north. A British Parliamentary Committee interested itself in the subject as long ago as 1749. At his third attempt (1770–1772) Samuel Hearne traced the course of the Coppermine river to the Arctic Ocean. But instead of the expected mountain of copper he found but one lump of the metal which he picked up among "a jumble of rocks," the fact being that for centuries the Eskimos and Coppermine river Indians had searched and exhausted the croppings for float metal, which they used as

an article of exchange over the whole north-west. As a result of the present expedition the author claims to have established that the ore in the Coppermine river rocks extends for some three hundred miles. Hanbury's expedition in 1902 proved the existence of an abundance of copper on the islands in Bathurst Inlet, so that if, as there is some reason to suppose, the Coppermine river rocks really re-appear in Victoria Land across the straits, the total area in which copper ore may possibly be found comes to nearly 10,000 square miles. To what extent this copper can be profitably worked can of course only be estimated after thorough survey. At present the region is inaccessible save to exploring parties, but the easternmost exposure of the copper-bearing rocks is stated to be not more than 500 miles from navigable water in Hudson Bay, over a possible railway route, while from the south a railroad is already projected to within eight hundred miles of their most westerly exposure. Lignite is plentiful within the Arctic circle, so that if the copper is otherwise commercially available, the fuel is to hand. Moreover, it is stated there is also soft coal.

The route of the present expedition was *via* the Athabasca and Mackenzie rivers, the Bear river and Great Bear Lake, and thence by the Dease river and the smaller lakes on the divide to the Coppermine river. This was the route followed by the earlier explorers on their journey from Canadian territory to the Arctic. The present party travelled by water throughout, by "scow" (a form of shallow-draught barge), the Hudson Bay Co.'s river steamers, their own canoes, and an open sailing-boat. The start was made from Athabasca Landing in May, and the same place was reached on the return journey, in October, eighteen months later. The five winter months were spent in a log-hut.

The book, which is not provided with an index, is plentifully illustrated with photographs, and contains a geological report by Dr. Sandberg, the scientific member of the party. The obvious pleasure and keenness with which the members of the expedition confronted the difficulties and risks of the journey make "Lands Forlorn" bracing, exhilarating reading. And if the record of their investigations encourages others to a more detailed investigation of this part of the Barren Lands, so much the better.

Adventures in Africa. By J. B. Thornhill. Pp. ix + 330, Demy 8vo. (London: John Murray, 1915.) Price 10*s.* net; post free, United Kingdom 10*s.* 10*d.*, abroad 11*s.* 2*d.*

The scenes of Mr. Thornhill's varied African adventures are under the Belgian-Congo, and Portuguese flags. He has worked in the Belgian Congo for a British Company

under the late Mr. George Grey, and for the Belgians and—in Angola—for the Portuguese. The latter experience enables him to throw some light on the indentured-labour system in that Colony.

Mapping, intelligence work, and road and railway surveying and making were Mr. Thornhill's principal occupations, and a considerable period of his time in Africa was spent in Katanga, Belgian Congo.

Mr. Thornhill, like all men who take part in pioneer work, has had endless adventures, and turned his hand to many different kinds of jobs. And what he has seen and done he puts down in a straightforward, breezy style. His judgments on men and things are uncompromising, and at times inconsistent, but he has the gift of making his writing extremely attractive. He is so delightfully and impulsively frank, so obviously recording things just as they struck him at the moment that—for the moment at all events—he carries the reader with him. Even the rather obvious undercurrent of disappointment at his own achievements in Africa which runs through it fails to detract from the interest of his story, and many of his observations, *e.g.* those about the merits and demerits of Belgian rule and methods in the Congo, are of particular interest.

The book is provided with a good map in colour of the Katanga District and an index.

Germany's Vanishing Colonies. By Gordon Le Sueur, with preface by Lt.-Col. A. St. H. Gibbons. Pp. 11 + 185, Demy 12mo. (London: Everett & Co., Ltd., 1915.) Price 2*s.* net; post free, United Kingdom and abroad, 2*s.* 3*d.*

This little volume traces briefly the history of the German colonies, laying stress on the importance of their raw material to Germany for utilisation in German factories to the advantage of German labour.

If it does not live up to the somewhat extravagant pretensions announced on the cover, it may serve as an introduction to the subject to the general reader, for it is quite elementary.

The World's Cotton Crops. By John A. Todd, B.L., Professor of Economics, University College, Nottingham. Pp. xiii + 460, Large Crown 8vo. (London: A. & C. Black, Ltd., 1915.) Price 10*s.* net; post free, United Kingdom 10*s.* 5*d.*, abroad 10*s.* 10*d.*

This work has been written with the object of affording a general survey of the relation between supply and demand in the case of cotton. It is pointed out that although a rapid increase has taken place in the world's cotton crops, there has been a still more rapid increase in

the demand, and it is therefore of considerable importance both to the grower and the user that they should have such a knowledge of the present sources of supply of the fibre and of the conditions under which it is produced as to enable them to judge the prospects of future supplies from existing cotton-growing lands and the possibilities of the development of new fields of production. The author has therefore given an account of the position of the industry in the various producing countries, the point of view throughout being that of the economist rather than of the botanist or agriculturist.

A brief account of the uses of cotton is given in order to demonstrate the great complexity and specialisation of the trade, and to indicate the diversity in the styles and qualities of cottons, from Indian to Sea Island, and the variety of purposes for which they are employed. Consideration is also devoted to the uses of cotton seed and the industries dependent on it.

The last chapter deals with the effects of the war on the cotton trade, and some interesting suggestions are made with regard to the future of the industry after the re-establishment of peace.

In order to avoid interrupting the text and distracting the reader's attention, the figures relating to production, consumption, and prices have been relegated to a statistical appendix.

The book is written in an interesting manner, and is furnished with a number of excellent photographs, diagrams, and maps. It is well up-to-date, and should prove of considerable service to all engaged in the cotton industry, whether as producers of the raw material or manufacturers of the various classes of cotton goods.

Practical White Sugar Manufacture, or the Manufacture of Plantation White Sugar directly from the Sugar Cane. By H. C. Prinsen Geerligs, Ph.D. Pp. xii + 184, Roy. 8vo. (London: Norman Rodger, 1915.) Price 12*s.* net; post free, United Kingdom 12*s.* 5*d.*, abroad 12*s.* 9*d.*

During recent years the methods of white cane sugar manufacture have been steadily improved by the application of the results of scientific research. Whereas manufacturers of raw sugar were formerly content to produce only refining crystals as a raw material for the refineries, they now make a white sugar directly from the sugar cane without remelting or using animal charcoal, and have succeeded in producing white cane sugar of high quality without incurring any very great increase in the cost of manufacture or excessive loss of sugar in the process. In the present volume, the different methods of achieving this end are described, and the relative advantages or dis-

advantages of the various processes and their modifications are discussed in detail.

The book is divided into three parts. The first part deals with the clarification of the cane juice, including (1) defecation methods, in which the clarification is effected with a comparatively small amount of lime; (2) carbonatation methods, in which a large amount of lime is used and the excess subsequently removed by carbonic acid; and (3) special methods, in which various agents or contrivances are employed. The second part describes the processes of boiling, curing, and finishing white sugar. The third part gives an account of the various chemicals and other materials used in the manufacture of plantation white sugar, together with the methods employed for their analysis at the Java Sugar Experiment Station. The work is well illustrated, and forms a useful addition to the literature of sugar manufacture.

MIKROGRAPHIE DES HOLZES DER AUF JAVA VORKOMMENDEN BAUMARTEN. Unter Leitung von Dr. J. W. Moll, bearbeitet von H. H. Janssonius. Vierte Lieferung. Pp. 338, Demy 8vo. (Leiden: E. J. Brill, 1914.) Price 3.60 gulden; post free, United Kingdom 6*s*. 4*d*., abroad 6*s*. 6*d*.

The first three parts of this treatise were noticed in this BULLETIN (1912, **10**, 183), to which reference may be made for particulars of the general scope of the work. The present part describes the microscopic structure of Java woods belonging to the families Connaraceæ, Leguminosæ, Rosaceæ, Saxifragaceæ, Hamamelidaceæ, and a portion of the Rhizophoraceæ. Altogether eighty-two species and varieties are dealt with, of which fifty-three belong to the Leguminosæ. The book will be of value to all interested in the identification of tropical woods, such well-known Indian timbers, for example, as *Dalbergia latifolia*, *Pterocarpus indica*, and *Albizzia Lebbek* being among those dealt with.

MINING WORLD INDEX OF CURRENT LITERATURE, vol. vi., last half-year 1914. By G. E. Sisley. Pp. xxvii + 234, Med. 8vo. (Chicago: The Mining World Company, 1914.) Price $2; post free, United Kingdom 8*s*. 8*d*., abroad 8*s*. 11*d*.

This is an international bibliography of mining, compiled and revised semi-annually from the index of the world's current literature published weekly by the *Mining and Engineering World*. As in previous volumes, an attempt has been made in this index to cover all publications that deal with mining, metallurgy, and kindred subjects. A new feature in this volume is the inclusion, in many of the entries, of a brief explanation outlining the contents of

the publication mentioned. This feature adds greatly to the usefulness of the volume, which is a well-compiled and valuable bibliography.

The Chemists' Year Book, 1915. Edited by F. W. Atack, M.Sc. Tech. (Manchester), B.Sc. (Lond.). Vol. I., pp. 354; Vol. II., pp. 560, Foolscap 8vo. (London and Manchester: Sherratt & Hughes.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 10*d.*, abroad 11*s.*

Until now British chemists have had to be content with a calendar and year book in German. This was an unsatisfactory position, because German conditions are so different from British that a desk reference book of this kind cannot be compiled to suit both. Messrs. Sherratt & Hughes are to be congratulated on their enterprise in taking advantage of the opportunity created by the war to replace the German article by a British one. The new Year Book contains a diary (three days per page) and all the usual information that a chemist is likely to require for reference. In publications of this kind the chemistry of plant products is apt to be neglected, and it is satisfactory to find that that is not the case in this instance, there being useful chapters on tanning materials, textile fibres, oils and fats, essential oils, rubber, tobacco, and alkaloids.

The Year Book is well arranged and easy to use, and it is to be hoped that the demand for it will prove large enough to warrant the publishers in continuing to issue it annually.

BOOKS RECEIVED

Forage Plants and their Culture. By Charles V. Piper. Pp. xxi + 618, Crown 8vo. (New York: The Macmillan Company, 1914.) Price 7*s.* 6*d.* net; post free, United Kingdom 7*s.* 11*d.*, abroad 8*s.* 3*d.*

Citrus Fruits. By J. Eliot Coit. Pp. xx + 520, Crown 8vo. (New York: The Macmillan Company, 1915.) Price 8*s.* 6*d.* net; post free, United Kingdom 8*s.* 11*d.*, abroad 9*s.* 4*d.*

Plants and their Ways in South Africa. By Bertha Stoneman, D.Sc. New edition, revised and enlarged. Pp. xii + 387, Crown 8vo. (London: Longmans, Green & Co., 1915.) Price 5*s.*; post free, United Kingdom 5*s.* 4*d.*, abroad 5*s.* 7*d.*

Industries in British East Africa. "South Africa" Handbooks, No. 80. Pp. 28, Royal 16mo. (London: "South Africa" Offices, 1915.) Price 6*d.*; post free, United Kingdom and abroad, 6½*d.*

First Principles of Production. By J. Taylor Peddie, F.S.S. Pp. 231, Crown 8vo. (London: Longmans, Green & Co., 1915.) Price 5*s*. net; post free, United Kingdom 5*s*. 4*d*., abroad 5*s*. 5*d*.

Australia *v*. Germany: The Story of the Taking of German New Guinea. By F. S. Burnell. Pp. 254, Crown 8vo. (London: George Allen & Unwin, Ltd., 1915.) Price 3*s*. 6*d*. net; post free, United Kingdom 3*s*. 10*d*., abroad 3*s*. 11*d*.

Who Caused the War. By Edward Kylie. Pp. 86, Demy 8vo. (London: Humphrey Milford, 1915.) Price 6*d*. net; post free, United Kingdom and abroad, 7½*d*.

The "South Africa" Map of South-West Africa, 1915. (London: "South Africa" Offices, 1915.) Price 1*s*.; post free, United Kingdom and abroad, 1*s*. 2*d*. Mounted on cloth 2*s*. 6*d*.; post free, United Kingdom and abroad, 2*s*. 9*d*.

The American Fertilizer Handbook. 8th Annual Edition. Pp. 402, Crown 4to. (Philadelphia: Ware Bros. Company, 1915.) Price $1·00, postage paid.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

ILLIPÉ NUTS AND THE SOURCES OF BORNEO TALLOW

THERE has been for some time a confusion as to the source of the fat known as Borneo tallow, due largely to the variety of native names for the seeds yielding it, and to the uncertainty as to the botanical identity of the trees from which the seeds are derived.

The Imperial Institute has been in communication with various scientific and other authorities on the subject, from whom a considerable amount of useful information has been obtained, and is specially indebted to Mr. K. Heyne, Curator of the Museum for Economic Botany, Buitenzorg, Java, in this connection.

The seeds and kernels of several species yielding Borneo tallow have been obtained, and their fats submitted to chemical examination. The information so far collected and the results of examination of the fats are recorded in the following pages. In view of the fact that the nuts yielding Borneo tallow generally come on the market under the name of illipé or illipi "nuts," it has been thought advisable to give also a brief account of the true illipé "nut" of India, the product of species of *Bassia*.

BORNEO TALLOW

This is the name under which the fat derived from various members of the family Dipterocarpaceæ, which grow in Borneo, Sumatra, and Java, is marketed in Europe.

The fat is known by the natives as "minjak tengkawang" (tengkawang fat), variations of the name, such as tangkawang, kakowang, and kawang, being also met with. The most important source of the fat is the seed of *Shorea stenoptera*, Burck. Others from which it is stated to be obtained are *S. Gysbertsiana*, Burck, *S. aptera*, Burck, *S. compressa*, Burck, *S. falcifera*, Dyer, ex Brandis, *S. Martiniana*, Scheff, *S. scaberrima*, Burck, *S. Pinanga*, Scheff, *Isoptera borneensis*, Scheff, *Hopea aspera*, De Vriese, and *Pentacme siamensis*, Kurz.

The fruits of these trees are mostly egg-shaped, and vary in size according to the species. They have the persistent winged calyx characteristic of the Dipterocarpaceæ; this is sometimes larger and sometimes smaller than the fruit itself; it is always removed, as well as the pericarp, before the kernels are shipped.

The different trees, as well as the fats obtained from them, are mostly distinguished by the natives by special names added to the name tengkawang. The shelled nuts are known as "padi tengkawang." As already mentioned, they are generally met with in the European markets under the misleading name "illipé nuts," to which is prefixed the name of a town in Borneo (Pontianak or Sarawak). They are marketed under different designations, the chief distinction being one of colour; the black nuts are the best, containing, according to Lewkowitsch, up to 68 or 69 per cent. of fat, while the brown ones contain only 48 to 50 per cent. The name Pontianak appears generally to be used in connection with the better quality (black) nuts, but the distinction between the names of towns attached to the nuts does not necessarily correspond to the difference in colour. The two grades at present most commonly met with in the market appear to be "large black Pontianak illipé nuts," and "large Pontianak or Sarawak illipé nuts without guarantee of colour."

The exact nature of the difference between the black and brown nuts does not appear to have been determined. It has been suggested by some that they represent seeds of different degrees of ripeness, and by others that they are derived from different species or varieties of trees, but

both these suggestions are contradicted by competent authorities, and it seems quite probable that the difference is due to variation in treatment. Specimens of both grades have been received at the Imperial Institute and submitted to the Director of the Royal Botanic Gardens, Kew, who stated that both kinds of nuts appeared to be those of a species of *Shorea*, near *S. stenoptera*.

A smaller kind of nut, yielding a softer fat, is met with on the market as "Siak illipé nuts," and it is to distinguish them from these small nuts that the additional prefix "large" is applied to the Pontianak and Sarawak nuts. The Siak nut is however not the product of any member of the Dipterocarpaceæ family, but of a species of *Palaquium*, which belongs to the same family as *Bassia*, viz. Sapotaceæ. This nut can properly be called by the same name (illipé) as Bassia seeds, but its fat resembles Borneo tallow, and it is probably on that account that the name illipé has been applied to the Pontianak and Sarawak nuts.

Harvesting and Treatment of the Fruit

The harvesting of the Borneo tallow fruits (*Shorea* spp.) has not been at all systematised, and their cultivation cannot properly be said to be undertaken at all. In Borneo *Shorea stenoptera* is sometimes planted on land that has yielded two or three crops of rice; but no attention is given to it until, after some twelve years, it begins to yield fruit. In Sumatra this tree does not occur, and other species are similarly grown. The flowering-time is towards the end of the dry season in September and October, the fruits reaching maturity in February and March.

The fruiting of the trees depends upon the weather. The best crops are obtained when the dry season is prolonged and passes gradually into the wet season. Heavy showers at the close of the dry season, accompanied as they usually are by strong winds, are very detrimental to the crops, the flowers and young fruits being broken off.

The requisite weather conditions are so frequently absent that the flowering of the trees is very irregular,

giving rise to the local statements that they only flower at intervals of five years, or at even longer intervals, sometimes extending to ten years (Cf. *Sarawak Gazette*, April 3, 1908; and *British North Borneo Herald*, April 16, 1909). It seems, however, to be incorrect that the fruiting of the trees is governed by any such periodicity, the irregularity being due solely to the rarity of the necessary weather conditions.

Some species of trees are less dependent upon these conditions than others, and it might be possible by proper cultivation and selection to effect an improvement in the irregular yield of the trees and to make them a more dependable source of supply.

When the fruits are ripe they fall spontaneously, and the harvesting simply consists in picking them up in the forests, an occupation which keeps the natives and their families busy for a length of time which depends upon the weather. On this point Mr. Heyne writes: "If the weather is favourable—that means if the weather is very bad—the crop is soon over; but sometimes it takes six to eight weeks before everything is collected."

In the case of *Isoptera borneensis*, which grows usually on river banks, the fruits fall into the rivers, where they are caught in nets, or they are gathered at the bends of the rivers, where they often collect. It is stated that the fruits of other species also are sometimes gathered from the rivers in this way.

After harvesting, the winged calices are removed, being frequently bitten off by the natives, and then the nuts are shelled. There are several processes by which this is done; but the best results are obtained by the soaking process. By this method the nuts are placed in bamboo baskets in the rivers, being kept submerged to prevent germination. They are soaked thus for thirty or forty days, or sometimes longer, after which time the shells have become weak, or have even burst, allowing of their easy removal from the kernels, which then generally split into four parts. Not only is the removal of the shell facilitated by the soaking, but the kernels prepared in this way are said to be less liable to attack by insects, probably

owing to the fact that the soluble carbohydrates are dissolved out.

This method, however, owing to the time required for the preparation of the kernels, is not much used at the present time. For export purposes the nuts are now generally placed in a damp place and allowed to germinate; the shells can then be removed, the sprouts are broken off, and the kernels dried. This process, however, is detrimental to both the quantity and quality of the fat.

Another process by which long soaking is avoided, is to treat the nuts with boiling water, which facilitates decortication. For native consumption they are frequently simply dried in the sun or over a fire, and the shells removed.

A certain amount of fat is still expressed locally; but the greater part of the kernels are now shipped to Europe, where they are pressed by up-to-date methods. A considerable portion of the East Indies produce is transported to and eventually shipped from Singapore, which, in 1913, exported 8,277 cwts., valued at £5,954, of which 6,326 cwts. were consigned to Belgium, 930 cwts. to the United States, and 923 cwts. to the United Kingdom. A large proportion of these exports were derived from the Dutch East Indies, the imports into Singapore in 1913 being 3,940 cwts. from the East Coast of Sumatra, and 571 cwts. from Dutch Borneo.

Examination of the Fats of the Different Species at the Imperial Institute

In addition to the Pontianak nuts already mentioned the seeds of *Isoptera borneensis* and *Palaquium oblongifolium* have been examined.

No. 1. "*Large black Pontianak nuts*."—These consisted of the segments into which the cotyledons separate on drying, mixed with broken fragments. The segments were of firm texture, nearly black in colour, curved longitudinally, roughly triangular in cross-section, and varied considerably in size, the largest being 1·9 in. long.

The nuts contained 4·1 per cent. of moisture and yielded 60·9 per cent. of hard, greenish-white, solid fat.

No. 2. "*Large Pontianak or Sarawak nuts without guarantee of colour.*"—These were similar in appearance to sample No. 1, but were brown in colour. They contained 4·4 per cent. of moisture, and yielded 53·2 per cent. of fat, similar to that from the foregoing sample.

As already mentioned, both kinds of nuts were identified at the Royal Botanic Gardens, Kew, as those of a species of *Shorea*, near *S. stenoptera.*

The fats obtained from the nuts were examined with the results given in the following table, which also shows the results obtained in the case of other samples of Borneo tallow as well as of cocoa butter.

	Present samples examined at the Imperial Institute.		Fat[1] from "Grosses graines de Pontiac" (probably *Shorea stenoptera*).		Fat from nuts of *Shorea Ghysbertsiana.*[2]	Commercial samples of Borneo tallow.[3]	Cocoa butter.[4]
	No. 1.	No. 2.	Variété rouge.	Variété noire.			
Specific gravity at $\frac{100° C.}{15° C.}$	0·8523	0·8535	—	—	0·856	0·892	0·8577
Solidifying point of fatty acids	53° C.	53·5° C.	52° C.	—	53° C.	52°–54° C.	48·3°–49·6° C.
Acid value[5]	35·0	32·0	—	—	—	—	—
Saponification value[5]	194·5	194·3	193·7	201·7	190·8	192·4–196	191·8–194·5
Iodine value . *per cent.*	31·0	31·4	28·8–31·2	34·1–37·4	30·0	29·4–31	34·3–37
Hehner value	95·6	94·6	—	—	96·1	95·7	94·59
Insoluble fatty acids, *per cent.*	95·0	93·8	—	—	95·8	—	—
Unsaponifiable matter, *per cent.*	0·6	0·8	0·8	—	0·3	—	—
Volatile acids, soluble[6]	nil.	nil.	—	—	—	—	—
" " insoluble[6]	0·4	0·5	—	—	—	—	—
Melting point	31°–32° C.	32°–33° C.	36·5° C.	—	33°–37° C.	34·5°–45° C.	28·3°–33·6° C.

[1] *Bontoux quoted in Lewkowitsch's* "*Oils, Fats and Waxes*" (5th ed., Vol. II., p. 602).

[2] *Brooks* (*Analyst*, 1909, **34**, 206).

[3] *Lewkowitsch* (*loc. cit.*, p. 603).

[4] *Lewkowitsch* (*loc. cit.*, pp. 588, 589).

[5] *Milligrams of potash for* 1 *gram of oil.*

[6] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of oil.*

These results show that the fats from the "black" and the "brown" nuts were practically identical, whilst the figures obtained agree fairly closely with those given by commercial Borneo tallow.

No. 3. *Isoptera borneensis.*—This sample consisted of small, dark chocolate-coloured, irregularly shaped cotyledons, together with a few whole kernels. The latter were somewhat flattened spheres, their maximum size being

$\frac{1}{2}$ in. by $\frac{3}{8}$ in. The material as received contained 6·6 per cent. of moisture, and yielded 43·5 per cent. of greenish coloured, tasteless, hard, firm fat. The latter was examined with the following results, compared with those obtained by Brooks in the case of a sample of "teglam" fat obtained by natives from the seeds of *I. borneensis* (*Analyst*, 1909, **34**, 207).

	Fat prepared at the Imperial Institute.	Native-prepared fat.[1]
Specific gravity at $\frac{100^\circ C.}{15^\circ C.}$	0·8563	0·856
Solidifying point of fatty acids	52·4° C.	51° C.
Acid value	8·5	11·3
Saponification value	190·7	192·1
Iodine value . . . . *per cent.*	31·8	31·5
Hehner value	94·9	95·7
Insoluble fatty acids . *per cent.*	93·9	95·2
Unsaponifiable matter . *per cent.*	1·0	0·5
Volatile acids, soluble	0·5	—
Melting point	29° C.	28°–31° C.

[1] *Brooks* (*loc. cit.*).

No. 4. *Palaquium oblongifolium.*—This sample consisted of dark brown kernels, covered with white bloom. They varied in length from $\frac{1}{2}$ in. to $\frac{7}{8}$ in., and in breadth from $\frac{5}{16}$ in. to $\frac{11}{16}$ in. One whole seed was present in the sample. This had a thin, brittle, dark brown, shiny shell, with a large hilum. The kernels contained 4·8 per cent. of moisture, and yielded 53 per cent. of greenish cream-coloured, hard, very firm fat. The latter, which was tasteless, and possessed an odour somewhat resembling that of cocoa butter, gave the following results on examination, compared with figures for the fat of *P. oblongifolium* quoted by Lewkowitsch (*loc. cit.*, p. 575).

	Fat extracted at the Imperial Institute.	Results quoted by Lewkowitsch.
Specific gravity at $\frac{100^\circ C.}{15^\circ C.}$	0·8553	—
Solidifying point of fatty acids	58° C.	—
Acid value	7·0	—
Saponification value	190·4	201·5
Iodine value . . . *per cent.*	35·9	34·3
Hehner value	95·3	—
Insoluble fatty acids . *per cent.*	94·3	—
Unsaponifiable matter . *per cent.*	1·0	—
Volatile acids, soluble	0·2	—
Melting point	38° C.	40° C.

Uses of Borneo Tallow.—This fat is used for edible purposes by the natives, and it also finds some use in Europe for candle-making and similar purposes, but its chief value is probably as a substitute for cocoa butter, which it resembles closely in analytical constants. When prepared from imported nuts, it resembles that product in taste and smell, though the native-prepared fat is crude and of unpleasant flavour. The cake remaining after expression of the fat is marketed as "illipé cake."

Mowra and True Illipé Fats

Mowra and illipé are names applied to the seeds of two species of *Bassia* (N.O. Sapotaceæ), viz.: *B. latifolia* and *B. longifolia*. According to Watt (*The Commercial Products of India*, 1908, p. 116), these trees are both known by the same native names, viz.: "mahua," "mahwa," or "mowha" (Hindustani), and "illupei," "illupai," or "illipi" (Tamil). But *B. latifolia* occurs chiefly in Central and East India, and is not found in the South, while *B. longifolia* only grows in Southern India; so that the former is generally known by the Hindustani names, and the latter by the Tamil names. Indeed, it is commonly stated that mowra fat or butter is the product of *B. latifolia*, and illipé fat or butter that of *B. longifolia*. This generalisation is, however, not always true. The seeds of the two species resemble one another in appearance, and in the nature of the fat which they yield, and the fats obtained from them, as met with on the market, are frequently the mixed product of both.

The following constants were obtained for fats extracted from authentic specimens of kernels at the Imperial Institute (see this Bulletin, 1911, **9**, 228):

	B. latifolia.	*B. longifolia.*
Specific gravity at $\frac{100° \text{C.}}{15·5° \text{C.}}$	0·857–0·862	0·856–0·861
Saponification value	188·3–199·8	195·3–202·7
Acid value	31·8–41·8	19·7
Iodine value . . *per cent.*	57·6–61·5	54·8–60·0
Volatile acids, soluble	0·2–0·9	2·35
Unsaponifiable matter, *per cent.*	2·0	1·4–2·2
Solidifying point of fatty acids	43·2°–46° C.	45° C.

Uses of Mowra and Illipé Fats

These fats are used in India for edible purposes, as a substitute for tallow, and for adulterating ghee (melted butter). In Europe they are used chiefly in the manufacture of soap and candles, though it is stated that *B. longifolia* fat is also used as a chocolate fat. These fats are pleasant in taste and smell when prepared by modern methods, but frequently the reverse when made by natives.

The cakes left after expression of the fats are alleged to have poisonous properties, and can, therefore, only be used as manures, though attempts have been made to render them suitable for cattle food. The question of their use for this purpose is discussed in this BULLETIN (*loc. cit.*). The products of *B. latifolia* and *B. longifolia* are dealt with in the above-mentioned article, together with those of *B. butyracea*. The fat derived from the last-named is known under the native name "phulwa"; it is harder than mowra and illipé fats, and is largely used for edible purposes in India, very little of it being exported.

REMARKS

The principal interest of all these fats, from the point of view of European industry, is that they are especially suitable for the manufacture of edible fats, and especially of the fats known as chocolate fats, and used for incorporation with cocoa powder in the preparation of chocolate for eating purposes. For this purpose it is highly desirable that the kernels should be exported as fresh as possible, and it is clear, from the results recorded above, that this is not secured at present, nearly all the fats examined having high acid values, due to their becoming rancid owing to the way the kernels are treated, and to the length of time they are kept before being exported. It is difficult to see how this can be remedied, so long as the supply of kernels remains a minor forest industry, dependent on collection from naturally occurring trees by natives. Something might be done by systematising the collection of the seeds, and ensuring their rapid transit to a centre, where they could be shelled by machinery, and shipped to Europe promptly. The total industry is however so small

that it is not easy to secure the necessary organisation. The only other method would appear to be the formation of plantations of the trees in one or other of the British Eastern Colonies, but the objection to this course is that the trees seem to take a long time to come into bearing, and the yield is uncertain.

MADIA SATIVA SEED FROM SOUTH AFRICA

Madia sativa, Mol. (Nat. Ord. Compositæ) is an erect annual closely allied to the sunflower. It is a native of Chile and California, and in the latter country forms a very troublesome weed. The plant has been cultivated for its seeds, which yield a yellowish oil, in a number of countries, including Algeria and parts of Asia Minor, where it is said to grow well. According to Haldane (*Subtropical Cultivations and Climates*) the plant stands a considerable degree of frost and grows best on a sandy soil; the yield of seed is stated to be 5½ to 6 cwts. per acre.

With a view to ascertaining the suitability of the plant to South African conditions, it was grown last year at the National Botanic Gardens, Kirstenbosch. The land on which it was cultivated proved to have been much exhausted by previous cultivation, and the plants were consequently somewhat starved, but in spite of this the yield of seed is stated to have been considerable. It is proposed to give the plant a more extensive trial this year under more favourable conditions, and if the experiment proves successful it is hoped to establish its cultivation on waste land in the Cape Districts in order to supply the local soap factories with oil.

A sample of the seed grown at the National Botanic Gardens, Kirstenbosch, was received for examination at the Imperial Institute in February last from Dr. H. H. W. Pearson.

The sample consisted of long, narrow seeds, measuring about ¼ in. in length and about $\frac{1}{16}$ in. in breadth, with tough husks which were mostly of a silver-grey colour, though a few were black. The average weight of a hundred seeds was 0·65 gram.

The seeds as received contained 5·1 per cent. of moisture, and yielded 36·5 per cent. of a yellowish-brown, liquid oil, equivalent to 38·4 per cent. from the dry seeds.

The oil was chemically examined with the following results:

	Present sample.	Previous results quoted by Lewkowitsch.[1]
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·9252	0·9285
Solidifying point of fatty acids	21·7° C.	20°–22° C.
Acid value[2]	2·2	—
Saponification value[2]	194·5	192·8
Iodine value . . . *per cent.*	128·9	117·5–119·5
Hehner value	95·8	—
Insoluble fatty acids . *per cent.*	95·0	—
Unsaponifiable matter *per cent.*	0·8	—
Volatile acids, soluble[3]	0·1	—
" " insoluble[3]	0·7	—

[1] *Chem. Techn. and Anal. of Oils, Fats and Waxes*, 5th ed. Vol. II. (1914), p. 146.
[2] *Milligrams of potash for* 1 *gram of oil.*
[3] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of oil.*

This *Madia sativa* oil appears to be of the "semi-drying" class, as it does not dry completely, either alone or in conjunction with "driers." It would thus be unsuitable for making paint, but it could be used for burning and for the manufacture of cheap soap. It may also prove suitable for use as an edible oil.

The residual meal left after the extraction of the oil at the Imperial Institute was examined with the following results:

	Per cent.
Moisture	8·11
Crude proteins	30·19
Consisting of:—	
True proteins	24·29
Other nitrogenous substances	5·90
Fat	0·55
Starch, etc. (by difference)	28·81
Fibre	26·14
Ash	6·20

The meal had a mild and not objectionable taste. No indications of the presence of alkaloids or cyanogenetic glucosides were obtained, and although the meal frothed when shaken with water no saponin could be detected.

If obtained by the crushing of the seed on a commercial scale, the residual meal would probably contain about

7 per cent. of fat, and its composition would in that case be as shown in the following table, in comparison with the corresponding results for commercial sunflower seed cake and undecorticated cotton seed cake:

	Madia sativa meal. *Per cent.*	Sunflower seed cake. *Per cent.*	Cotton seed cake (undecorticated). *Per cent.*
Moisture	7·6	7·1	13·75
Crude proteins . . .	28·2	19·0	24·62
Fat	7·0	7·4	6·56
Starch, etc. (by difference) .	27·0	28·9	29·28
Fibre	24·4	30·0	21·19
Ash	5·8	7·5	4·60
Nutrient ratio[1] . . .	1 : 1·5	1 : 2·4	1 : 1·67
Food units[2] . . .	114	94	107

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to* 2·5 *times the sum of the percentages of fat and crude proteins.*

From these figures it will be seen that the percentage of crude proteins in *Madia sativa* meal is higher than in either sunflower or undecorticated cotton seed cake, and as the general composition of the three materials is similar, the *Madia sativa* meal should have a rather higher food value than the other two products, which, in common with it, have the disadvantage of containing a rather high percentage of fibre.

In view of these results it seems that *Madia sativa* meal would probably be of value for cattle-feeding, but practical feeding trials will be necessary before a definite opinion can be expressed on this point. The husks of the seeds are very tough, and might possibly prove an obstacle to the use of the material for feeding purposes.

Madia sativa seed does not appear to have been hitherto employed on any considerable scale as a source of oil, and technical trials would be necessary to determine definitely the uses and value of both the oil and the residual meal.

"OWERE" SEEDS (*MONODORA MYRISTICA*) FROM THE GOLD COAST

Monodora Myristica, Dun. (Nat. Ord. Anonaceæ), is a tree reaching 50–60 feet in height, found in the tropical rainforests of West Africa, but introduced to other parts of the

tropics, including the West Indies, where it is cultivated under the name of "calabash nutmeg." It is said to be well-distributed throughout the more open country in Ashanti, and the seeds are plentiful at certain seasons. The seeds are used by the natives of West Africa as a condiment, and also for the preparation of various native medicines.

In August 1913 a large fruit weighing $1\frac{3}{4}$ lb., a leaf, and about $\frac{3}{4}$ oz. of seeds from the Gold Coast were received at the Imperial Institute. The pericarp of the fruit had become rotten during transit, and the seeds were therefore picked out and dried. The dried seeds, which measured about $\frac{7}{8}$ by $\frac{3}{16}$ in., were oblong in shape, and of a brown colour. They possessed a thin, somewhat brittle testa, and a hard, oleaginous interior.

The seeds sent separately had evidently been obtained from a fresh fruit, and were considerably lighter in colour than those extracted from the fruit forwarded to the Imperial Institute.

The leaf and a few of the seeds were sent to the Royal Botanic Gardens, Kew, for determination, and were identified as those of *Monodora Myristica*, Dun.

On steam distillation the seeds yielded 5·9 per cent. of a colourless volatile oil, which possessed an agreeable lemon-like odour and taste. The oil was examined with the following results:

Specific gravity at $\frac{15° C.}{15° C.}$	0·849
Optical rotation in 100 mm. tube at 20° C.	$-44° 40'$
Acid value	1·2
Ester value, before acetylation	1·9
" " after acetylation	52·9
Solubility in alcohol	Soluble in 6 or more volumes of 90 per cent. alcohol.

This volatile oil appeared to consist largely of terpenes, but the quantity available was too small for detailed examination.

The residue left after the steam distillation yielded a quantity of fixed oil amounting to about 36 per cent. of the original weight of the seeds. This fixed oil was liquid, slightly viscous, and of a reddish-brown colour. It possessed a faint smell, probably due to the traces of the essential oil.

A chemical examination of the fixed oil gave the following results:

Specific gravity at $\frac{15° C.}{15° C.}$	0·919
Acid value	20·2
Saponification value	186·7
Iodine value . . . *per cent.*	118·4

As it was considered that these "Owere" seeds might be of economic value as a source of oil if they were obtainable in commercial quantities, a larger supply of the seeds was obtained from the Gold Coast for detailed examination and technical trial.

This consignment, which was received in July 1914, weighed 76 lb., and consisted of oblong, brown seeds, with a thin shining outer skin and a hard oleaginous interior. In a considerable proportion of the seeds the thin outer skin was absent. A large number of the seeds were worm-eaten, and the sample had a mouldy smell.

The seeds were not in such good condition as the previous sample, and were rather lighter in colour.

The results of examination of the volatile and fixed oils and the residual meal were as follows:

Volatile Oil.—On steam distillation the seeds yielded 2·2 per cent. of volatile oil, compared with a yield of 5·9 per cent. from the previous small sample. The volatile oil obtained from the second supply of seeds was pale yellow, and its odour was rather less pleasant than that of the colourless oil obtained from the earlier sample. The small yield of volatile oil and the inferior aroma may probably be attributed to the poor condition of the present seeds.

The oil was examined with the following results, compared with the figures previously obtained:

	Present sample.	Previous sample.
Specific gravity at $\frac{15° C.}{15° C.}$	0·8592	0·849
Optical rotation	$-57·8°$ at 25° C.	$-44·7°$ at 20° C.
Acid value	1·4	1·2
Ester value, before acetylation	6·4	1·9
" " after acetylation	33·50	52·9
Solubility in alcohol	Soluble in 4·5 or more volumes of 90 per cent. alcohol.	Soluble in 6 or more volumes of 90 per cent. alcohol.

Fixed Oil.—The residue left after the steam distillation yielded a quantity of dark, reddish-brown, fixed oil, amounting to about 35 per cent. of the original weight of the seed, which is about the same yield as was obtained from the previous sample. This oil, which possessed a strong smell of the essential oil, was submitted to chemical examination with the following results:

		Present sample.	Previous sample.
Specific gravity at $\frac{15.5° C.}{15.5° C.}$		0·917	0·919
Acid value[1]		56·7	20·2
Saponification value[1]		180·6	186·7
Iodine value	*per cent.*	110·6	118·4
Hehner value		94·4	—
Insoluble fatty acids	*per cent.*	92·8	—
Unsaponifiable matter	*per cent.*	1·6	—
Volatile acids, soluble[2]		1·0	—
„ „ insoluble[2]		0·23	—

[1] *Milligrams of potash for* 1 *gram of oil.*
[2] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of oil.*

Residual Meal.—The residual meal left after the extraction of both oils from the seeds was examined as a feeding-stuff, and the results of the analysis are shown in the following table:

	Per cent.
Moisture	1·0
Crude proteins	17·6
Fat	2·8
Starch, etc. (by difference)	29·1
Fibre	47·4
Ash	2·1
Nutrient ratio	1 : 2
Food units	80

The Owere seed meal did not contain any alkaloids or cyanogenetic glucosides. It had no pronounced taste, but it was not attractive in appearance, and contained a large amount of fibre. It does not appear likely to be suitable for use as a feeding-stuff and could probably only be used as manure.

The volatile and fixed oils were submitted for valuation to soapmakers and essential oil distillers, and the following reports were obtained:

(1) *Volatile Oil.*—This oil was provisionally valued at

about 2*s.* per lb. (May 1915) by a firm of essential oil distillers, who stated, however, that a detailed examination of the oil would be necessary to establish its value definitely. Another firm, after carefully investigating the oil, expressed the opinion that its value would be about equal to that of the oil of *Eucalyptus amygdalina*, or possibly a little more, say 1*s.* to 1*s.* 6*d.* per lb. A firm of soap manufacturers, after practical tests, reported that as an essential oil for perfuming soap this Owere oil would have a relatively low value, viz. 1*s.* to 1*s.* 3*d.* per lb. A second soap-making firm stated that their experiments with the oil did not give satisfactory results, as it is somewhat lacking in character and in permanence of odour. They mentioned that the odour of the oil, though pleasant, is not distinctive, and they considered that in compound perfumes the same effect could be better obtained by using oils of higher odour value.

(2) *Fixed Oil.*—A firm of soap manufacturers who were consulted regarding the commercial value of the fixed oil did not consider that it would be suitable either for soap-making or for edible purposes. Considerable difficulty was experienced in saponifying the oil, and the resulting soap was found to be of very poor colour. The manufacturers stated that if the oil were obtained at a very low price and in large quantities a suitable method of refining it might be devised, but that otherwise it would be of little interest for soap-making.

A second firm of soapmakers confirmed this view, and stated that they were extremely doubtful whether any large market for the oil could be created amongst soap-makers. The oil would probably only compete with low-grade oils which are used for the manufacture of soft soap and which command only a low price.

It will be seen from these reports that the prospects of finding a market for the fixed oil are not very promising, and that the essential oil is not likely to realise more than 1*s.* 6*d.* to 2*s.* per lb. In view of these results, it seems quite certain that it will not be possible to utilise these Owere seeds commercially so long as other and better oil seeds are available at cheap rates, as is the case at present.

TURPENTINE OIL AND RESIN OF *BOSWELLIA SERRATA* FROM INDIA

Boswellia serrata, Roxb. (Nat. Ord. Burseraceæ), is an Indian tree allied to those which yield the true frankincense or olibanum of commerce from Somaliland, and is sometimes known as the Indian olibanum tree. According to Watt (*The Commercial Products of India*, London, 1908, p. 174), there are said to be two varieties—*B. serrata* proper, a moderate-sized, gregarious tree of the intermediate northern and southern dry zones, and *B. serrata* var. *glabra*, a native of North-West India. A gum-resin exudes from the tree on injury, and in the Punjab this is collected twice a year—in March from incisions made in the previous October, and in June from incisions made in March. It is computed that each tree yields annually about 2 lb. of gum-resin. The latter is employed by the natives in the treatment of rheumatism and nervous diseases, and is an ingredient in certain ointments. In Gujerat it is burnt as incense in religious ceremonies. There is a small export of the gum-resin from India, amounting to 778 cwts., of value £1,339, in 1913–14, most of which was shipped to Germany and Austria-Hungary.

As the only outlet for the gum-resin at present is the small demand for incense, experiments have been conducted at the Forest Research Institute, Dehra Dun, with a view to ascertaining the best method of treating the crude gum-resin in order to obtain turpentine oil, resin, and other products. According to information supplied to the Imperial Institute by Mr. R. S. Pearson, Forest Economist to the Government of India, the gum and impurities were separated from the resin and oil by treating a quantity of the raw product in a false-bottomed copper still and passing steam through the mass by means of a compound steam coil fitted with spur-pipes. By this means small quantities of the most volatile constituents were distilled off, but the resin and most of the oil passed through the false bottom, leaving the gum and impurities above. The oil was then separated from the resin by steam distillation and the resultant oil fractionally distilled up to 155° C., yielding

turpentine oil, consisting almost wholly of dextro-pinene, and a portion consisting mostly of limonene or dipentene (see *Rep. Bd. Sci. Adv. for India*, 1913–14, p. 17). A sample of each of these fractions was forwarded to the Imperial Institute for examination, together with two samples of resin, and the results of the investigation of the turpentine oil and resins are dealt with below.

Boswellia Turpentine Oil

The sample consisted of a mobile liquid oil with a slight greenish-yellow tinge and a sweet, agreeable odour.

The oil on being examined at the Imperial Institute was found to have the following constants:

	Boswellia turpentine oil.	Commercial turpentine oil. American.	Commercial turpentine oil. French.
Specific gravity at $\frac{15° C.}{15° C.}$	0·8446	0·858 to 0·877	0·865 to 0·875
Optical rotation a_D . .	+31° 24′	+9° 30′ to +14° 17′ (rarely slightly lævo-rotatory)	−29° to −33°
Ester value, before acetylation . . .	2·6	—	—
Ester value, after acetylation . . .	36·4	—	—

On fractional distillation the Boswellia oil gave the following results:

Fraction boiling at	Per cent.
153° to 160° C.	89
160° to 180° C.	11

The fraction boiling at 153° to 160° C. was re-distilled, and practically the whole passed over at 155° C.

For comparison with these figures it may be stated that 85 per cent. of American turpentine oil usually distils between 155° and 163° C., and 85 to 90 per cent. of French oil between 155° and 165° C.

It was found that the Boswellia turpentine oil readily dissolved resins such as colophony, dammar, sandarac, and soft copal, but that varnishes prepared in this way dried more rapidly than those made with commercial turpentine oil and gave a rather less lustrous surface.

In order to obtain technical opinions as to the probable

value of this Boswellia turpentine oil, samples were submitted to several turpentine oil merchants and distillers and to varnish manufacturers likely to be interested in the product. The general opinion expressed was (1) that the oil is of very good quality and closely resembles American turpentine oil, except as regards the smell, which is regarded as peculiar though not unpleasant, and (2) that the Boswellia oil could be successfully employed like ordinary turpentine oil in the manufacture of varnishes.

All the firms consulted thought that the Boswellia oil would be readily saleable in the United Kingdom. One firm stated that its commercial value should be approximately equal to that of American turpentine oil, though the difference in smell alluded to might constitute a slight drawback. Another firm considered that the oil would find a ready market in the United Kingdom if it could be sold at about 25 per cent. under the price of American turpentine oil, and a third valued it at about 30*s.* per cwt., with American turpentine oil at 37*s.* per cwt.

The rapid drying of this Boswellia turpentine oil is possibly due to the removal by distillation in India of the higher-boiling fractions. It was found at the Imperial Institute that a mixture of 10 parts of Boswellia turpentine oil and 1 part of the higher-boiling residual Boswellia "essence," which had been thus removed in India, gave a somewhat better result in varnish-making than the turpentine oil alone. This view is further borne out by the fact that when the higher-boiling fractions were removed from commercial turpentine oil the resulting distillate yielded a quicker-drying varnish somewhat inferior to that obtained with the original oil.

It thus seems probable that a product even more closely resembling commercial turpentine oil could be produced by modifying the distillation of Boswellia turpentine oil so as to include a portion of the higher fractions, and that this oil would be more suitable for use in varnish manufacture than the oil represented by the present sample. As a guide to what is required, it may be suggested that the Boswellia oil should be made to conform as far as possible to American turpentine oil in range of boiling point.

Boswellia Resin

Two samples of resin prepared in different ways in India were received.

No. 1.—This was obtained by allowing the residual resin, prepared as described on p. 351, to dry in the open air over a hot-air bath. It consisted of dark brown, very brittle resin, in the form of flat, broken pieces, fragments, and dust. The fracture was vitreous. The resin resembled colophony in odour and was practically tasteless.

The resin was examined with the following results, compared with those obtained in India (*loc. cit.* p. 18):

		Results obtained at the Imperial Institute.	Results recorded by the Forest Chemist in India.
Moisture	*per cent.*	0·7	—
Ash	*per cent.*	0·5	—
Melting point		72° C.	—
Acid number		51·5	49·6
Saponification number		92·0	73·9
Iodine value	*per cent.*	70·0	105·04
Specific gravity at $\frac{20^\circ C.}{20^\circ C.}$		1·082	1·054

The resin was completely soluble in alcohol, ether, alcohol and ether, chloroform, benzene, benzene and alcohol, turpentine oil, turpentine oil and alcohol, turpentine oil and benzene.

A varnish prepared from 1 part of the resin and 1 part of turpentine oil gave on sized wood a fairly brilliant coat which dried slowly and chipped off easily.

No. 2.—This sample was obtained by heating the resin in a still by a gentle fire. It consisted of three large slabs, and a few fragments, of dark, greenish-black, very brittle resin. The fracture was vitreous. The resin had a slight "burnt" odour, but no taste.

The resin gave the following results on examination, compared with those obtained in India (*loc. cit.* p. 18):

		Results obtained at the Imperial Institute.	Results recorded by the Forest Chemist in India.
Moisture	*per cent.*	0·9	—
Ash	*per cent.*	0·4	—
Melting point		56° C.	55°–59° C.
Acid number		25·0	15·99
Saponification number		66·0	27·25
Iodine value	*per cent.*	96·0	119·1
Specific gravity at $\frac{20^\circ C.}{20^\circ C.}$		1·050	1·087

The resin was partly soluble in alcohol, and completely soluble in ether, ether and alcohol, chloroform, benzene, benzene and alcohol, turpentine oil, turpentine oil and alcohol, turpentine oil and benzene.

A varnish prepared from 1 part of the resin and 1 part of turpentine oil gave on sized wood a coat similar to that obtained with the preceding sample No. 1, but less brilliant and of a darker colour.

It will be seen from the foregoing results that some of the constants obtained for these samples of resin at the Imperial Institute differ considerably from those recorded by the Forest Chemist in India. It is clear, however, from the low acid and saponification values that the Boswellia resin is quite unlike ordinary colophony in composition.

With regard to the possible ways of utilising this Boswellia resin, the following remarks may be made:

(1) *As a Paper Size.*—The greater part of the Boswellia resin does not saponify when treated with alkali, and this fact renders the resin quite unsuitable for the preparation of a resin size. Attempts to prepare size at the Imperial Institute by boiling the resin with sodium carbonate solution in the usual way were unsuccessful, as only a small portion of the resin dissolved.

(2) *For Varnish Manufacture.*—Both samples of resin yielded varnishes of poor quality which dried rather slowly and easily chipped off. For varnish-making they would not compete with ordinary colophony, which now realises from 12*s.* 6*d.* to 18*s.* per cwt., ex wharf, less 2½ per cent. discount, and tare 20 per cent. in the United Kingdom (May 1915), and is itself only used for the manufacture of varnishes of low grade.

(3) *As a Substitute for Colophony.*—The dark colour and neutral character of the Boswellia resin would only permit of its competition with the lower grades of colophony, and would not allow of its use, for example, in the manufacture of resin soap. It might, however, be employed in the preparation of cheap, dark-coloured sealing-wax and similar compositions, but for these purposes there is only a limited market, which is generally amply supplied.

Further experiments were made at the Imperial Insti-

tute in order to ascertain whether the Boswellia resin would yield useful distillates when submitted to dry distillation. In a small-scale trial the following fractions were thus obtained:

Sample No. 1

Fraction distilling at	*Per cent.*	Description.
100°–150° C. (chiefly at 130° C.)	8·4	A limpid, reddish-brown liquid.
150°–360° C. (chiefly from 240° to 340° C.)	38·4	A limpid, dark reddish-brown liquid.
Above 360° C. . . .	7·4	A brownish-green liquid.
Residue	45·8	A rather soft pitch.

Sample No. 2

Fraction distilling at	*Per cent.*	Description.
Up to 150° C. . . .	4·0	A limpid, yellowish-brown liquid, floating on a darker layer.
150°–250° C. (chiefly from 240° to 250° C.)	26·7	A limpid, greenish liquid.
250°–310° C. (chiefly from 295° to 305° C.)	17·6	A limpid, green liquid, lighter in tint than the above distillate.
Above 310° C. . . .	22·8	A rather thick, brown liquid, containing much solid matter.
Residue	28·9	Pitch.

Ordinary French rosin distilled under the same conditions gave the following results:

Fraction distilling at	*Per cent.*	Description.
Up to 150° C. (chiefly from 100° to 110° C.)	6·7	A limpid, greenish-yellow liquid, floating on a colourless layer.
From 150° upwards (chiefly above 360° C.)	66·9	A viscous, greenish-brown, turbid liquid, showing slight fluorescence.
Residue	26·4	Very viscous pitch.

It is thus clear that Boswellia resin behaves differently from ordinary rosin when distilled, and yields a different set of products. It would, therefore, be impossible to use Boswellia resin as a substitute for colophony in the manufacture of rosin oils.

For further information regarding the methods available for the utilisation of neutral resins of the Boswellia type, see this BULLETIN, p. 374.

SOME LITTLE-KNOWN RESINS

THE principal use to which resins are applied in industry is the manufacture of varnishes. In order that a resin may be used in this way it must have the property, when

dissolved in a suitable vehicle, of forming a thin "coat" when applied to wood, paper, cloth, metal, or other like substances. This varnish "coat" must be resistant to the action of the air and moisture, and it must, in most cases, be transparent and pale-coloured so that it will not obscure the character or other qualities of the material to which it has been applied. The necessity for the possession of these properties severely limits the number of naturally occurring resins which can be applied to the manufacture of varnishes, and the copals, dammars, sandaracs, mastic, shellac, and a few others of minor importance, exhaust the list. The commonest of all resins, viz. rosin or colophony, is unsuitable for the preparation of high-grade varnishes. If a solution of rosin in turpentine oil or alcohol is applied to sized wood, and the latter is set aside to dry, a transparent continuous "coat" is undoubtedly formed. But sooner or later this "coat" becomes dull, and eventually finely granular, and in this condition it is easily rubbed off. Raw rosin is, therefore, but little used for the preparation even of cheap varnishes. This dulling of the "coat" yielded by rosin varnish is due to the fact that the rosin gradually crystallises, and thus loses the continuity and transparence that are essential qualities of a varnish-resin. Fortunately there are a number of ways in which the tendency of rosin to crystallise can be reduced or entirely overcome, and these discoveries have made it a valuable raw material to the makers of varnishes and certain kinds of paints. All these methods of improving rosin into a useful varnish- and paint-material depend on the fact that it is almost entirely composed of a resin acid, which can be caused to combine with lead, zinc, manganese, and other metallic oxides to form resinates, which are soluble in or miscible with the vehicles generally used in varnishes and paints. There are, however, a large number of naturally occurring resins which show, to an even greater extent than raw rosin, this tendency to crystallise, and are therefore unsuitable for use as varnish-materials. A few of them can possibly be improved by the methods which are employed in the case of rosin, but the great majority are composed of neutral substances and, therefore, are not capable of

much improvement by such methods, and at present some of them are practically valueless, since no industrial outlet has been found for them. It is the purpose of the present article to call attention to a number of these products, which have been examined recently at the Imperial Institute. The products are of two types—resinous latices and elemis.

RESINOUS LATICES

The term latex is applied to the milk-white fluids elaborated by certain plants and secreted usually in a special system of glandular tissue in the plants. Latex may vary widely in composition; but in general it consists of finely divided solid substances or highly viscous liquids, suspended in water containing small quantities of salts and other substances dissolved in it. The substances suspended in latices show great variation in nature, depending on the plants from which the latices are derived. Thus the drug opium is the dried latex of the opium poppy; gamboge is a dried latex, and consists chiefly of gum and yellow resin; natural raw rubber is the coagulum from the latices yielded by various rubber trees. The best natural rubbers, such as those obtained from the Para and Ceara rubber trees, consist mainly of caoutchouc, and contain, when well prepared from trees of suitable age, only small quantities of moisture, protein, and resin. The inferior natural rubbers are inferior mainly because they contain considerable quantities of impurities, especially resin. There is, in fact, a gradual transition from such a high-grade product as the best quality of plantation Para rubber, containing as much as 95 per cent. of caoutchouc and less than 1 per cent. of resin, to such products as the coagulated or dried latices of some of the euphorbias, which may contain over 90 per cent. of resin and only 2 or 3 per cent. of material which is either caoutchouc or has some resemblance to that substance. It is to these materials in which resin is the dominant constituent that the term "resinous latices" is applied. A number of these products containing from 10 to 20 per cent. of caoutchouc, the rest being mainly resin, have acquired considerable

commercial importance, since they can be used to a certain extent for mixing with rubber in the manufacture of certain kinds of rubber goods. In the last few years attempts have been made to use some of them as sources of rubber by removing the large quantities of resin they contain by means of suitable solvents. The resins thus extracted are at present waste products, and in spite of the fact that various projects have been put forward for their utilisation, there is no satisfactory evidence that they are being employed industrially to any large extent at present.

A typical resinous latex is that yielded by *Dyera costulata*, the coagulum from which comes on the market under the names "jelutong," "pontianac," "bresk," "dead Borneo," etc., and has long been used for mixing with rubber. According to a statement published in the *India Rubber World* (1912, **47**, October 1, p. 49), it has been found possible to separate the rubber and the resin contained in the latex from this tree in forms suitable for use in industry. For this purpose the crude jelutong is said to be subjected to pressure to remove the excess of water. The pressed residue is treated with a solvent under pressure to extract the resin. The latter is then recovered by draining the solution from the crude rubber, which is left undissolved, and removing the solvent by distillation. The jelutong resin thus obtained can be dissolved in hot alcohol or turpentine oil, but such solutions on cooling yield a crystalline deposit, and the liquor poured from this deposit, when used as a varnish, gives a film which dries with a frosted or crystalline appearance. The material in this form is obviously unsuitable for varnish manufacture. A previous article in the same journal (1911, **42**, November 18, p. 20), however, stated that if this crude "jelutong resin" is heated to 600° F. for an hour it loses about 20 per cent. of its weight, and thus yields a product which can be dissolved in oil of turpentine, yielding a solution which does not deposit crystalline matter on standing. Moreover, such a solution, when used as varnish, is said to give a glossy, transparent coat. Further, it is claimed that such a solution can be mixed with the ordinary driers and drying oils used in varnish manufacture. If these claims

can be substantiated, it is obvious that this process will enable resins of the jelutong type to be employed for the manufacture of at least an inferior kind of varnish.

Attempts have also been made, apparently, to distil jelutong resin for oil in the same way as poor qualities of rosin are used for the manufacture of rosin oil (compare p. 363 of this article, and also *India Rubber World*, 1912, **47**, October 1, p. 49).

A large number of resinous latices have been examined at the Imperial Institute, and the results of some of this work have already been published in "Selected Reports from the Scientific and Technical Department," Part IV. (*Colonial Reports—Miscellaneous* [Cd. 6022], 1912, especially pp. 411–434). The following products have been examined since the issue of that publication:

Euphorbia Resin from Natal

Two samples of Euphorbia resin from Natal were received in January 1910. The first sample consisted of two large lumps and several small pieces of a dark brown, semi-translucent resin, slightly sticky externally. The material was readily friable, yielding a yellowish powder possessing a faint, unpleasant smell.

The second sample consisted of two large lumps and several pieces of dark-coloured, semi-translucent resin, a little sticky externally. The resin was friable, yielding a pale yellow powder with a faint, rather unpleasant smell.

These resins were examined with the following results:

		No. 1.	No. 2.
Moisture	*per cent.*	0·40	0·54
Ash	*per cent.*	0·04	0·18
Melting point (approx.)		61° C.	58° C.
Acid number		7·9	7·9

Both resins were completely soluble in the ordinary solvents. On standing, the solutions readily deposited "semi-crystalline" matter.

These samples behaved like typical Euphorbia resins. For conversion into varnishes they would have to be dissolved in turpentine oil or alcohol, and, as already

indicated, they sooner or later separate from such solutions in the form of "semi-crystalline" masses. Varnishes prepared from these resins would, even if applied while still clear, crystallise on the surfaces to which they were applied, and gradually produce a rough opaque layer. Moreover, the resins have low melting points, and for this reason, even if the disadvantage of crystallisation could be overcome, the "coats" produced by varnishes made from them would be liable to become soft and sticky in hot weather.

Similar difficulties to those described occur to a less extent with cheap varnishes made from common rosin, but in this case they can be overcome by converting the rosin into metallic "lakes." Unfortunately this process is not practicable in the case of these Euphorbia resins, since they consist of neutral substances, which will not form "lakes."

The samples were submitted to a firm of varnish and colour manufacturers, who, after careful examination, found that on account of their low melting points and their tendency to crystallise from solution they are of no practical value for varnish-making.

It has also been suggested that the Euphorbia resins would form excellent materials for the preparation of anti-corrosive paints; but the manufacturers report that the properties referred to render them quite unsuitable for this purpose.

Latex of *Euphorbia Tirucalli* from Natal and Mauritius

In May 1911 a sample of material, described as "crude latex from the *Euphorbia Tirucalli*," was received from Natal, with the request that it should be examined in order to determine the amount of rubber and resin present, and if possible the value of these constituents when separated.

The sample consisted of a cubical block of material which was greyish-white externally, and had a greenish tint within when freshly cut. The external layers were hard and rather brittle, whereas the internal portion was

sufficiently soft to be moulded in the fingers; the material became plastic on warming.

A sample of similar material, which, however, possessed a strong rancid odour, was received from Mauritius in September 1912.

Both samples were examined by the method employed for the analysis of rubbers, and the following results were obtained:

	Sample from Natal.		Sample from Mauritius.	
	Material as received.	Composition of dry material.	Material as received.	Composition of dry material.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	32·4	—	63·6	—
Caoutchouc	9·7	14·3	4·3	11·8
Resin	51·2	75·8	28·8	79·1
Proteins	0·9	1·3	0·7	1·9
Insoluble matter	5·8	8·6	2·6	7·2
Ash	2·5	3·7	1·8	4·9

In order to investigate the nature of the resin, a larger quantity of this constituent was prepared from the Natal sample of the crude material by extraction with solvents.

The resin was transparent, brownish-yellow, and brittle. It gave the following results on examination:

Moisture . . . . *per cent.*	0·77
Ash . . . . *per cent.*	0·11
Melting point (approx.)	55° C.
Acid number	4·0
Saponification value	47·0

The resin was completely soluble in turpentine oil, chloroform, and benzene, and in mixtures of alcohol and ether, alcohol and turpentine oil, alcohol and benzene, and benzene and turpentine oil. It was not completely soluble in alcohol or acetone, but dissolved in ether with the formation of a cloudy solution. The resin readily crystallised from its solution in most organic solvents on standing, and was quite similar in general properties to the two samples of Euphorbia resin from Natal already described.

In order to determine the suitability of the resin for the

manufacture of varnish, solutions of different strengths in turpentine oil were tested on sized mahogany in comparison with copal and dammar varnishes. It was found that strong solutions of this Euphorbia resin yielded a "matt surface" devoid of lustre when applied to wood, owing to the crystallisation of the resin, whilst weaker solutions yielded surfaces of poor lustre, which remained sticky for several days.

By using a mixture of this Euphorbia resin with dammar, varnishes showing some lustre on drying could be prepared, but these remained sticky for two or three days, whereas a varnish made with the dammar alone dried in about one day.

Further experiments were made by "melting" the Euphorbia resin before dissolving it in turpentine oil, as is done in the case of copal resin.

The resin was heated over a naked flame for about twenty minutes, and was then dissolved in turpentine oil, forming a dark solution. This solution gave a varnish of very moderate lustre, which remained sticky for two or three days. The resin, after being heated, did not appear to crystallise so readily from the solution as the unmelted resin.

Mixtures of the crude resin with turpentine oil and linseed oil were made, but the resin crystallised quite readily from these solutions, and would therefore be of little value for the preparation of an oil-varnish by this process.

As this Euphorbia resin did not appear to be suitable for the preparation of varnishes, experiments were made in order to determine whether it would yield on dry distillation products resembling the "rosin spirit" and "rosin oils" obtained in this way from common rosin. When submitted to dry distillation the Euphorbia resin decomposed and furnished a liquid distillate, which was separated into three fractions, together amounting to 82 per cent. of the resin, and a black, pitch-like residue.

The results of the distillation are shown in the following table, together with the characters of the three liquid fractions:

	Approx. yield. *Per cent.*	Description.	Specific gravity.	Bromine absorbed. *Per cent.*	Acid value.
Fraction 1.	18·0	Mobile greenish-brown liquid with a tarry odour. Boiling point 145°–300° C.	0·891	122	—
Fraction 2.	21·5	Greenish-yellow oily liquid. Boiling point over 300° C.	0·948	133	2·7
Fraction 3.	43·0	Dark greenish-brown, highly fluorescent, viscous oil.	0·967	108	2·7
Residue (pitch)	8·3	—	—	—	—
Acid, aqueous liquid, gas and loss.	9·2	—	—	—	—

The liquid distillates, fractions 1, 2, and 3, were completely soluble in alcohol.

It appears from these results that this Euphorbia resin behaves generally like colophony on dry distillation, in that it yields liquid distillates of low specific gravity and high bromine absorption. The higher fractions of the distillate appear, however, to contain less "resin acids" than the corresponding fractions from colophony, and they are soluble in alcohol, whereas both "rosin spirit" and "rosin oils" are stated to be insoluble in alcohol. It will, however, be necessary to make further distillations on a larger scale, and to examine the products in detail, in order to determine whether they are similar to those obtained from colophony, and whether they could be utilised for similar purposes.

A further sample of the latex of *Euphorbia Tirucalli* from Natal was received in December 1913. It was stated that the sample represented the crude latex which had been sterilised in the steam steriliser at the Laboratory of the Agricultural Department in Pretoria.

The sample consisted of about 15 oz. of latex which had partially coagulated during transit. After removing the solid material, the liquid latex was coagulated and the two portions of the coagulum were then mixed together before analysis. The latex furnished 35·5 per cent. of dry coagulum.

The solid coagulum was a hard, tenacious material,

which became greenish-yellow on exposure to the air. It closely resembled in appearance and physical properties the sample of the coagulated latex of *Euphorbia Tirucalli* from Natal previously submitted to the Imperial Institute (see p. 361).

The composition of the dry coagulum is shown in the following table, which also includes the figures for the previous sample received at the Imperial Institute:

	Present sample.	Previous sample.
	Per cent.	*Per cent.*
Caoutchouc	15·7	14·3
Resin	82·1	75·8
Proteins	1·3	1·3
Insoluble matter	0·9	8·6
Ash	1·5	3·7

It will be seen from these figures that the present sample is generally similar in composition to the previous sample prepared in Natal, containing a high percentage of resin and a low percentage of caoutchouc. The present sample includes much less insoluble matter than the earlier specimen, and hence the percentages of both resin and caoutchouc are somewhat higher.

In connection with the above reports it is of interest to mention that the *Agricultural Journal of the Union of South Africa* (1913, **5**, 706) contains an article by Mr. Herbert Noyes, describing the Natal Tirucalli rubber industry, in the course of which it is pointed out that about 25,000 lb. of the coagulum from *Euphorbia Tirucalli* was being produced monthly in Natal at that time. As regards the resin from this material Mr. Noyes states: "It was our original intention to inaugurate an extraction process similar to that in use by producers of Guayule, Balata, etc., with a view to separating the rubber and resinous contents of the coagulum—by which term the solidified latex is known—and as it had been ascertained that the rubber came up to within 80 per cent. of the value of the best Para and that the resin had a specific value, there is no doubt that such an undertaking would have succeeded. But subsequent enquiries, tests, and practical demonstrations proved that there existed a very great demand for the coagulum

in its crude and unconcentrated form. Further, that if the manufacturers of rubber articles, who found the Tirucalli product admirably adapted for mixings, etc., were assured of a uniform supply, there was every possibility of the price increasing." The value of the coagulum in Europe is given in the same article as 8*d.* per lb.

"Tshizimboti" Latex from Rhodesia

A sample of coagulated "Tshizimboti" latex was received from Rhodesia in March 1914. It was stated that the plant is found in the Enkeldoorn district of Southern Rhodesia, and that the latex is utilised by the natives for preparing a kind of bird-lime.

Herbarium specimens of the "Tshizimboti" tree were also forwarded for identification, and on examination at the Royal Botanic Gardens, Kew, they were found to represent two species of Euphorbia, both of which may be new. In these circumstances further specimens will be required in order to establish the botanical identity of the tree.

The sample consisted of a soft, resinous, brown substance, with a slight cheesy odour; internally the material was of a cream tint. It was submitted to chemical analysis with the following results, compared with the corresponding figures for a sample of *Euphorbia Tirucalli* latex from Natal examined at the Imperial Institute:

	"Tshizimboti" latex.		*Euphorbia Tirucalli* latex.	
	Composition of material as received.	Composition of dry material.	Composition of material as received.	Composition of dry material.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	19·4	—	32·4	—
"Caoutchouc"	6·6	8·1	9·7	14·3
Resin	54·4	67·5	51·2	75·8
Proteins	2·0	2·5	0·9	1·3
Insoluble matter	17·6	21·9	5·8	8·6
Ash	3·9	4·8	2·5	3·7

It will be seen that the coagulated "Tshizimboti" latex is of very resinous character, only 8·1 per cent. of "caoutchouc" being present in the dry material, and that it contains a large percentage of insoluble matter.

The resin, as extracted by acetone, was golden-brown in colour, transparent, and brittle, and had a slight sweetish

odour. A mass of crystals separated out from a saturated solution of the resin in acetone on standing.

On analysis the resin gave the following results:

	Resin from "Tshizimboti" latex.	Resin obtained at the Imperial Institute from *Euphorbia Tirucalli* latex from Natal.
Saponification value	48·2	47·0
Acid value	5·1	4·0
Melting point	57° C.	55° C. (approx.)

The resin closely resembled, both in appearance and its chemical constants, the resins extracted from various samples of Euphorbia latex from South Africa previously examined at the Imperial Institute.

The residue left after extracting the resin with acetone was a brownish, friable substance. It contained a large amount of insoluble matter, consisting principally of salts of calcium, etc., and only a little real caoutchouc.

This coagulated Tshizimboti latex was generally similar in composition to samples of Euphorbia latex previously examined at the Imperial Institute. It contained, however, much less caoutchouc and more insoluble matter than the product prepared from *Euphorbia Tirucalli* latex in Natal, and it is doubtful, therefore, whether it would find a market in competition with the latter material.

Latex of *Euphorbia canariensis* from the Canary Islands

A sample of the coagulated latex of *Euphorbia canariensis* was received from the Canary Islands in December 1912. The coagulated product as received at the Imperial Institute was a white, friable substance, containing a large amount of moisture and possessing a rancid odour. It was submitted to chemical examination with the following results:

	Expressed on material as received. *Per cent.*	Expressed on dry material. *Per cent.*
Moisture	62·6	—
"Caoutchouc"	4·7	12·6
Resin (acetone extract)	28·9	77·3
Proteins	1·0	2·7
"Residue"	2·8	7·4
Ash	1·5	4·0

The "residue" consisted of 2·5 per cent. of material soluble in water, chiefly calcium salts, and 0·3 per cent. of woody, insoluble matter.

It will be seen from these results that the material is very resinous, and that, as received at the Imperial Institute, it contained more than 62 per cent. of water. The dry product contained 77·3 per cent. of resin and only 12·6 per cent. of "caoutchouc," whilst 7·4 per cent. of material insoluble in organic solvents was present.

The "caoutchouc" exhibited very poor physical properties and was evidently of inferior quality.

The resin extracted by acetone was obtained as a hard, clear, amber-coloured substance on distilling off the solvent. Like most other Euphorbia resins, it crystallised readily from its solution in alcohol, and in this condition would be of no value for the preparation of varnishes.

The crude coagulum melted when heated on a water bath, forming a plastic mass, which, however, became brittle on standing.

In view of (1) the brittle nature of this coagulum, (2) the inferior quality of the "caoutchouc" which it contains, and (3) the fact that according to previous trials it cannot be vulcanised, it seems very doubtful whether it could be utilised for the same purposes as the material obtained in Natal from *Euphorbia Tirucalli*. Technical trials would, however, be required to determine this point definitely.

The present sample was coagulated by exposing the latex to the sun; but it would be worth while trying the effect of adding the usual coagulating agents (acids, salts, etc.), and the effect of heating the latex.

It is not possible to say definitely, without technical trials, whether this product could be utilised commercially; but in any case its value would be lower than that of *Euphorbia Tirucalli* from Natal.

Coagulated Latex of *Conopharyngia elegans* from the Transvaal

This product was received from the Transvaal in September 1911. It consisted of a circular cake of greyish-white material which became white on exposure to air,

The product was moist, fairly soft, and sticky. It was evidently of very resinous nature, and exhibited little elasticity or tenacity.

On analysis by the methods used for rubber it gave the following percentage results:

Loss on washing (moisture and impurities)	19·8
Composition of dry, washed product:	
Caoutchouc	14·8
Resin	72·8
Proteins	10·7
Ash	1·7

This material is of the Almeidina type. It was valued at about 3*d.* per lb. in Europe (February 1912), but it is doubtful whether this price would make its collection in the Transvaal remunerative.

Latex and "Gutta" of *Diplorrhynchus mossambicensis*

The samples which are the subject of this report were forwarded to the Imperial Institute from Beira in June 1907. The material submitted for examination consisted of a sample of latex and of the so-called gutta-percha obtained from it, together with botanical specimens of the plant from which they were derived.

The botanical specimens have been identified at Kew as *Diplorrhynchus mossambicensis*, Benth.

Latex

The sample of latex consisted of about half a pint of a creamy fluid, which furnished nearly three ounces of dry material on coagulation. The product was grey, rather sticky, and brittle.

The dry material contained 74·6 per cent. of resin and 1 per cent. of proteins. The remainder consisted of a soft, sticky substance resembling rubber of very inferior quality rather than "gutta," the characteristic constituent of true gutta-percha.

"*Gutta-percha*"

The sample consisted of a large cylindrical lump, which was black externally, but brown and somewhat moist within, and very sticky.

A chemical examination showed that the dry material contained 87·7 per cent. of resin, 2·2 per cent. of proteins, and 7·8 per cent. of insoluble matter. The residue, amounting to only 2·3 per cent., consisted of a brown friable powder which had none of the properties of "gutta."

This sample is much more resinous than the product prepared from the latex, and would have very little or no commercial value.

The Latex of the "Tufui" Tree (*Anthostema senegalensis*, Juss.) from Sierra Leone

This material was received from Sierra Leone in March 1911. The specimen consisted of a white, soft, sticky material, apparently a coagulated latex, which possessed considerable elasticity. It contained a quantity of small woody particles, evidently derived from the cut stem of the plant.

It gave the following percentage results on analysis:

	Composition of material as received.	Composition of dry material.
Moisture	28·8	—
"Caoutchouc"	4·1	5·8
Resin	63·9	89·7
Insoluble matter	3·2	4·5
Ash	0·7	0·9

The residue remaining after extraction of the resins with acetone was greyish-brown in colour. It had a certain amount of elasticity and was distinctly rubber-like, though weak.

This product is of very resinous character, and contains less than 6 per cent. of rubber-like material.

Rubber-like Substance from Southern Rhodesia

This material, which was described as a "rubber-like substance from an indigenous fig tree," was received in February 1913. It consisted of a single lump of a hard greyish material, which appeared to be very resinous. It exhibited fair tenacity, but little elasticity. It gave the following results on analysis:

	Per cent.
Loss on washing (moisture and impurities)	29·1
Composition of dry washed product:	
Caoutchouc	28·0
Resin	68·2
Proteins	1·0
Ash	2·8

This product is stated to be derived from a species of fig indigenous to Southern Rhodesia, and it resembles in composition the material furnished by *Ficus utilis*, Sim., in Natal. It also resembles in general appearance the material derived from *Euphorbia Tirucalli* in Natal, but is superior to it in composition, containing more caoutchouc and less resin.

It is impossible to state without technical trials (for which purpose this sample was too small) whether this product would be suitable for use as a mixing material in rubber manufacture. If satisfactory for this purpose, it might be worth from 6*d.* to 9*d.* per lb. in London.

"Rubber" from the Transvaal

This sample, which was received from the Transvaal in August 1911, consisted of a chocolate-coloured, pasty mass, which was very sticky, and could easily be drawn out into long threads. It exhibited none of the physical properties of true rubber and was evidently of very resinous character. It gave the following results on analysis:

	Material as received.	Composition of dry material.
	Per cent.	*Per cent.*
Moisture	26·0	—
"Caoutchouc"	8·7	11·8
Resin	56·6	76·4
Proteins	0·5	0·7
Insoluble matter	8·2	11·1
Ash	2·0	2·7

Considered as a rubber, this material is of very inferior quality, both as regards physical properties and chemical composition. The results of the analysis show that the dry material contains 76·4 per cent. of resin, and only 11·8 per cent. of caoutchouc. The latter was dark brown, and exhibited only very feeble elasticity and tenacity. The product would be of no value in its present condition, and

as the caoutchouc is of very low quality, and only occurs to the extent of 11·8 per cent. in the dry material, it would not be worth while to consider its extraction.

LATEX OF *MIMUSOPS CUNEIFOLIA* FROM UGANDA

The latex of *Mimusops cuneifolia*, which is the subject of this report, was received for examination in September 1913.

The sample consisted of a pinkish-white, milky fluid, which had a somewhat rancid odour.

Owing to the small quantity of latex available, only a general examination could be made. It was found that coagulation could be brought about by adding acetic acid to the latex and warming, and the dry coagulum obtained in this way from the 40 c.c. of latex weighed 10·2 grams, equal to a yield of 25·5 per cent.

The coagulum was a hard, friable, whitish material which had the following composition:

	Per cent.
Moisture	1·5
Rubber-like material	9·4
Resin	83·4
Insoluble matter	5·7

It will be seen from these figures that the coagulum was of very resinous nature, containing over 83 per cent. of resin, and less than 10 per cent. of rubber-like material. Owing to the friable nature of the coagulum, it does not appear likely that the material would be suitable for technical use as a "gutta." The resins present were hard, white, and crystalline, soluble in boiling alcohol, but almost insoluble in cold liquid, and could not therefore be utilised for varnish making, even if they were separated from the other constituents.

ELEMI RESINS

The name "elemi" is in commerce practically restricted to the soft, aromatic oleo-resin collected in the Philippine Islands, from a species of *Canarium*; but from time to time small quantities of similar resins from other localities come on the market, and are sold as "elemi," usually with the addition of a qualifying adjective to the name, which indi-

cates the country of origin, and serves to distinguish them from the product of the Philippines. Thus the oleo-resin of *Dacroydes hexandra* is known as "West Indian" or "dry elemi" in this country, though in the West Indies it is better known as "gommier resin." Similarly, from various parts of West Africa, such as Liberia, Cameroons, Southern Nigeria, and elsewhere, small quantities of an aromatic oleo-resin are received from time to time under the name of "West African elemi."

Until quite recently the botanical origin of the true elemi of commerce was not known with certainty, but as the result of an investigation carried out by officials of the Bureau of Science, established in the Philippines since these islands were annexed by the United States of America, it is now known that the oleo-resin is collected from *Canarium luzonicum* (Clover, *Phil. Journ. Sci.*, 1907, **2**, 2). The fresh oleo-resin contains from 25 to 30 per cent. of volatile oil, composed mainly of hydrocarbons, of which phellandrene forms by far the largest proportion. The non-volatile residue is of the nature of a resin, but, unlike these products in general, it is largely composed of readily crystallisable matter which can be separated into two well-defined substances, distinguished as α-amyrin and β-amyrin respectively.

At one time elemi was used in considerable quantities in medicine, as an ingredient in ointments and plasters, but this use has almost ceased, and at present it is mainly employed in the preparation of printing inks, and occasionally as an ingredient in varnishes. The small demand which exists for elemi appears to be readily met by the supplies obtainable from the Philippines.

In previous numbers of this BULLETIN (1904, **2**, 25; 1907, **5**, 186; 1908, **6**, 252), descriptions and analyses of elemis from various sources have been given, and it has been pointed out that the commercial demand for such products is very small, and is confined to the product from Manila. The number of products of this type seems, however, to be fairly large, and the trees yielding them widely distributed in the tropics, so that it is desirable that some industrial outlet should be found for them. The elemis are oleo-

resins, that is, they are natural solutions of resins in volatile oils, just as turpentine, as it exudes from pine trees, is a natural solution of resin in turpentine oil. On distillation in a current of steam, the elemis yield a *distillate* of volatile oil and a *residue* of resin. The latter consists of neutral substances, which crystallise or granulate very easily, and therefore, like the resins of the "resinous latices" described above, cannot be used in varnish manufacture. Small quantities of crude elemis are sometimes added to "spirit varnishes," but it is probable that the only advantage they confer is to give a certain elasticity to hard resins, such as shellac, and to confer a slight, but pleasantly aromatic, odour on the varnish. The Philippine Bureau of Science has given some attention to the possibility of finding a more extended use for Manila elemi, and among the experiments tried was that of mixing elemi resin (the residue left after the removal of the oil by distillation) with copal, "melting" the mixture in the usual way, and making the "melt" into varnish. It is claimed that such a mixture yields a varnish which dries in one or two days, is paler in colour than when made with copal alone, and yields a brilliant elastic coat, so long as the amount of elemi used is not more than half the quantity of copal employed (*Philippine Journal of Science*, 1909, **A. 4**, 100; 1910, **A. 5**, 200).

In the BULLETIN articles already referred to, elemis from the West Indies, Liberia, Nigeria, and Uganda have been described, and the following product of the same type has been examined since then.

OLEO-RESIN OF *CANARIUM COLOPHANIA* FROM MAURITIUS

A sample of the oleo-resin of *Canarium Colophania* was received from Mauritius in May 1912. It consisted of a thick, pasty, resinous substance, generally resembling the Manila elemi of commerce in appearance. It was of dirty cream colour, and possessed an aromatic lemon-like odour, resembling that of Manila elemi.

On being steam-distilled, the crude material yielded 16·6 per cent. of a volatile oil, and left about 75 per cent. of resin as residue.

The volatile oil was a mobile, straw-coloured liquid,

with an aromatic, lemon-like odour. It had the following constants:

Specific gravity at $\frac{15{\cdot}5^\circ\ C.}{15{\cdot}5^\circ\ C.}$	0·859
Specific rotation $[\alpha]_D$	$+3^\circ\ 13'$
Refractive index	1·4725

The resin was pale brown, transparent, and brittle. On examination it gave the following results:

Moisture	*per cent.*	1·8
Ash	*per cent.*	1·7
Acid value[1]		23·4
Saponification value[1]		31·5

[1] *Milligrams of potash for* 1 *gram of resin.*

The resin was more or less soluble in practically all organic solvents.

A portion of the resin was found to crystallise out from the solution in alcohol, showing that the material would be of little or no value in its crude state for varnish-making. The crystalline deposit resembled the amyrin obtained under similar conditions from commercial elemi.

This material could, at present, only be of commercial value as a substitute for true elemi. The demand for elemi in commerce is, however, very small, and is confined to the product exported from Manila. The oleo-resin of *Canarium Colophania* from Mauritius is similar to but not identical with Manila elemi, and it would be practically impossible to sell it in the United Kingdom at a remunerative price under present conditions.

COCOA FROM UGANDA

THE cultivation of cocoa in Uganda is of quite recent date. The first plantings were made in 1901 at the Entebbe Botanical Gardens from young plants sent from Kew. These trees first bore when five years old, and a sample of the beans examined at the Imperial Institute proved to be equal to good-quality Ceylon cocoa (this BULLETIN, 1907, 5, 22). The progress made was slow at first; but experience has shown that with proper care, especially in the matter of pruning, cocoa may be planted in Uganda with

a reasonable certainty of proving remunerative. Complete figures for the acreage under European cultivation are not available, but on 86 plantations from which returns were received in 1913–14, 500 acres were planted with cocoa under five years old, and 111 acres with cocoa over that age, while smaller areas are occupied by cocoa interplanted with Para rubber. It is stated in the Report of the Department of Agriculture for 1913–14 that an increased interest was taken in the cocoa crop during the year, and the demand by planters for cocoa pods far exceeded the supply.

At present cocoa in Uganda appears to be free from root diseases, no "canker" has been found, and cases of "die-back" have not been numerous. Crickets are sometimes destructive to young plants, but the only other insect pests of importance are scale insects and green-fly, both of which, however, are easily amenable to suitable treatment.

An experimental plantation was established recently at Kampala, the trees cropping for the first time in 1913–14 when 4½ years old. Altogether 78 trees were kept under observation, the yield of pods being as follows:

	Forastero cocoa.		Calabacillo cocoa.	
	Red varieties.	Yellow varieties.	Red varieties.	Yellow varieties.
Number of trees .	34	32	6	6
Average yield of pods per tree .	8·6	8·8	25	8·8

A sample representing the ungraded fermented cocoa produced on the Government Plantation at Kampala was received for examination at the Imperial Institute in February 1915.

The sample consisted of cocoa beans varying in size from large to very small, together with some undeveloped and broken beans. Most of the beans were fairly plump, but a large number, especially of the smaller beans, were thin.

The beans mainly varied in colour from cinnamon brown to dark brown, but a small number were of a purplish-brown tint. The break was easy, and in most cases of good colour, though in a few cases it was slaty.

The cocoa possessed a good aroma, and a fairly full taste, free from harshness.

After removal of the husks, which amounted to 7·3 per cent. by weight of the beans as received at the Imperial Institute, the beans were submitted to examination with the following results:

	Per cent.
Moisture	4·9
Total alkaloid	1·7
Fat	47·2
Ash	3·2

These results indicate that the composition of the beans was normal.

A graded sample consisting of fairly large and undamaged beans was prepared at the Imperial Institute from the original sample, and this, together with some of the ungraded beans, was submitted for valuation to brokers and manufacturers, who reported as follows:

The brokers described the graded sample as an excellent cocoa, well fermented and of good flavour, adding that the thinness of the shells was an advantage. They valued the product at 76*s.* to 78*s.* per cwt. in Liverpool (May 1915).

The firm considered the ungraded cocoa to be of rather lower value, viz. from 74*s.* to 76*s.* per cwt. in Liverpool, owing to the presence of smaller beans.

The manufacturers stated that the market value of the graded beans would approach that of good Grenada cocoa, though neither sample was so well fermented as the latter variety.

It should be pointed out in connection with the above reports that the prices realised for cocoa at the present time are exceptionally high, "common to fair" Grenada cocoa being quoted at from 77*s.* to 78*s.* 6*d.* per cwt. in the United Kingdom (June 2, 1915).

These results indicate that this cocoa from Uganda would be readily saleable in the United Kingdom at good prices.

HYBRID COFFEE FROM CEYLON

THE sample of coffee which is the subject of this report was received at the Imperial Institute in May 1915. It was stated to represent a hybrid coffee, probably of *C. arabica* and *C. liberica*, grown at the Peradeniya Experiment Station.

The sample consisted of coffee in the parchment. The beans were of a pale greenish-grey tint, and were covered with a thin brown skin; they were somewhat irregular in shape and varied in size from medium to small. The sample was clean and free from insect attack.

The parchment was first removed from the beans, the relative proportions by weight being as follows: parchment, 11·4 per cent.; beans, 88·6 per cent. The average weight of a single bean was 0·13 gram.

The beans, after removal of the parchment, were submitted to chemical examination with the following results:

	Per cent.
Moisture	11·7
Caffeine	1·7
Crude proteins	13·0
Consisting of:	
True proteins	9·1
Other nitrogenous substances (excluding caffeine)	3·9
Fat	7·8
Starch, etc. (by difference)	49·4
Fibre	12·6
Ash	3·7

The above results show that these beans of *Coffea Canephora* differ considerably in composition from the average raw coffees of commerce. The amount of caffeine present (1·7 per cent.) is above the average, the normal quantity in ordinary coffee being from 1·0 to 1·5 per cent., and the maximum figure recorded 1·8 per cent. On the other hand the percentage of crude fibre (12·6) is exceptionally low, the usual amount being from 20 to 30 per cent., and the lowest figure for a large number of analyses 16·6 per cent. The amounts of proteins, ash, and starch are normal, but the percentage of fat is decidedly low.

The coffee as received was submitted for valuation to brokers, who reported that the sample consisted of parch-

ment coffee which would have been improved by more careful washing. They valued the product, after husking, at 43*s.* per cwt., and stated that it would sell in competition with "Robusta" coffee, the Java variety of which is now worth from 46*s.* to 49*s.* per cwt. (June 1915) for washed beans of good quality.

KAFFIR CORN ("DARI") FROM SOUTH AFRICA

The three samples of Kaffir corn ("Dari") from South Africa which are the subject of this report were received at the Imperial Institute in June 1915.

No. 1. "*White.*"—This sample consisted of plump, white, very clean grains, in good condition, and practically free from insect attack.

No. 2. "*Red.*"—Plump grains of a brownish-red colour, mixed with a small percentage of white grains. The sample was in good condition and free from insect attack, but a small amount of dirt was present.

No. 3. "*Mixed White and Red.*"—Plump grains of the colours of samples 1 and 2, in good condition, and free from insect attack. A small quantity of dirt was present in the sample.

The samples were analysed at the Imperial Institute with the following results, which are shown in comparison with analyses recorded for White Dura from the Sudan, Red Sorghum from Zanzibar, and commercial Indian Dari:

	Sample No. 1. White.	Sample No. 2. Red.	Sample No. 3. Mixed.	White Dura from Sudan.	Red Sorghum from Zanzibar.	Indian Dari.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	11·93	12·00	11·73	8·45	10·0	12·5
Crude proteins	9·79	10·83	10·01	13·06	11·2	9·3
Consisting of:						
True proteins	9·57	10·66	10·01	12·98	10·8	—
Other nitrogenous substances	0·22	0·17	nil.	0·08	0·4	—
Fat	3·22	3·37	3·06	3·30	2·8	2·0
Starch, etc. (by difference)	72·50	71·01	72·58	72·45	72·1	72·3
Fibre	1·27	1·28	1·14	1·03	1·8	2·2
Ash	1·29	1·51	1·48	1·71	2·1	1·7
Nutrient ratio	1 : 8·2	1 : 7·3	1 : 8	1 : 6·1	1 : 7	1 : 8·25
Food units	105·0	106·5	105·2	113·3	107	101

These three samples of Kaffir corn appear to be quite normal in composition, and very similar in both composition and feeding value to the Indian Dari with which they were compared.

Information regarding the commercial value of the grain and its suitability for feeding and other purposes is given in an article on "The Utilisation of Sudan Dura" in this BULLETIN (1913, **11**, 33). For all the uses referred to in that article this South African Kaffir corn would be as suitable as the Sudan Dura.

COTTON FROM BRITISH GUIANA

IN an article on the "Field and Forest Resources of British Guiana," published in the last number of this BULLETIN (1915, **13**, 222), it was mentioned that experiments in the hybridisation of cotton have been carried on by the Department of Agriculture in that colony since 1908. A series of samples of hybrid cottons produced in the course of these experiments was received recently at the Imperial Institute, as well as a sample of Sea Island cotton and one of the indigenous cotton, known as "Native Buck." The latter is a perennial tree cotton, which grows with great vigour, is hardy, and gives a good yield of lint. The results of examination of these samples are given in the following pages:

Hybrid Cottons

Twelve samples of hybrid cottons were received. Most of them consisted of both ginned and unginned cottons, but two (Nos. 2 and 3) consisted of ginned cotton only. Samples Nos. 1–10 were the results of crosses made in 1907 at the suggestion of the Director of the Imperial Institute between Stirling Sea Island and the common red Native Buck cotton. The plants from which the lint was taken were of the F_4 generation, and their characters are stated to be fairly constant. Nos. 11 and 12 were crosses between Native Suwardi cotton and the "Sea Island and Native Buck" hybrid. The lint of Nos. 1–10 was very similar in appearance, being clean, fairly soft, lustrous, of cream

colour, and either free from stains or but slightly stained; that of the other two was similar, but it had a reddish tinge. The seeds, however, varied somewhat, as did also the strength, length, and diameter of the fibres, and these are dealt with separately below, together with the valuations of the lint. At the date of the valuations "best Barbados" Sea Island cotton was quoted at 1*s.* 2½*d.* per lb., and "best St. Kitts" at 1*s.* 4*d.* to 1*s.* 5*d.*

No. 1.—The seeds in this sample were large and black, without fuzz.

The cotton was of fairly good strength. The length varied from 1·5 to 1·9 in., but was mostly from 1·7 to 1·8 in., and the diameter ranged from 0·0005 to 0·00095 in., with an average of 0·00069 in.

It was valued at 1*s.* 2*d.* per lb.

No. 2.—This cotton was of fairly good strength. It varied in length from 1·3 to 1·8 in., but was mostly from 1·5 to 1·7 in.; the diameter of the fibres ranged from 0·0005 to 0·0008 in., with an average of 0·00064 in.

It was valued at 11*d.* per lb.

No. 3.—This cotton was also of fairly good strength. The length varied from 1·3 to 1·7 in., but was mostly from 1·5 to 1·6 in.; the diameter ranged from 0·0005 to 0·0008 in., with an average of 0·00063 in.

It was valued at 1*s.* per lb.

No. 4.—The seeds of this sample were large and black, with a small tuft of brownish-white fuzz at each end.

The lint was of fairly good strength, and varied in length from 1·3 to 1·8 in., but was mostly from 1·5 to 1·7 in. The diameter of the fibres ranged from 0·0005 to 0·0008 in., with an average of 0·00065 in.

The lint was valued at 1*s.* to 1*s.* 1*d.* per lb.

No. 5.—The seeds in this case were large and dark chocolate-coloured, with a small tuft of brownish fuzz at each end.

The strength of the cotton was fairly good, and the length varied from 1·6 to 2·2 in., but was mostly from 1·8 to 2·0 in. The diameter of the fibres ranged from 0·0004 to 0·00075 in., with an average of 0·00057 in.

The lint was valued at 1*s.* 1*d.* to 1*s.* 2*d.* per lb.

No. 6.—The seeds were black and of medium size, with a small tuft of brown fuzz at each end.

The lint was of good strength and varied in length from 1·5 to 2·0 in., but was mostly from 1·7 to 1·9 in. The diameter ranged from 0·0005 to 0·00075 in., with an average of 0·00060 in.

The ginned cotton was valued at 1*s.* 2*d.* per lb.

No. 7.—The seeds of this sample were black, of medium size, with a small tuft of brownish fuzz at the pointed end.

The lint was of fair strength on the whole. The length varied from 1·4 to 1·8 in.; but was mostly from 1·5 to 1·7 in. The diameter ranged from 0·0005 to 0·00095 in., with an average of 0·00066 in.

The lint was valued at 1*s.* per lb.

No. 8.—This sample had large black seeds, with a tuft of brownish fuzz at each end.

The lint was of fair strength, and was from 1·2 to 1·7 in. long, but mostly from 1·4 to 1·6 in. The diameter varied from 0·0005 to 0·0009 in., with at average of 0·00061 in.

It was valued at 1*s.* 2*d.* per lb.

No. 9.—The seeds in this case were large and chocolate-coloured, with a tuft of brownish or greenish fuzz at one or both ends.

The lint was of fairly good strength, and varied in length from 1·4 to 1·8 in.; but was mostly from 1·5 to 1·7 in. The diameter ranged from 0·0005 to 0·0010 in., with an average of 0·00066 in.

The lint was valued at 1*s.* per lb.

No. 10.—The seeds of this sample were also large and chocolate-coloured, with a tuft of brownish or greenish fuzz at both ends.

The lint was of fairly good strength, and varied in length from 1·4 to 1·9 in., but was mostly from 1·6 to 1·8 in. The diameter ranged from 0·0005 to 0·0009 in., with an average of 0·00063 in.

It was valued at 1*s.* to 1*s.* 1*d.* per lb.

No. 11.—The seeds of this sample were large and dark chocolate-coloured, with a tuft of white fuzz at the blunt end.

The lint was of good strength, and varied in length from 1·2 to 1·7 in., but was mostly from 1·4 to 1·6 in. The diameter ranged from 0·0005 to 0·00075 in., with an average of 0·00061 in.

It was valued at 1*s.* 2*d.* per lb.

No. 12.—The seeds in this case were also large and dark chocolate-coloured, but they possessed a small black spike at the pointed end and a tuft of white fuzz at the blunt end.

The lint was of fairly good strength, and the length varied from 1·4 to 1·8 in., but was mostly from 1·4 to 1·6 in. The diameter ranged from 0·0005 to 0·00085 in., with an average of 0·00063 in.

It was valued at 1*s.* per lb.

Sea Island Cotton

No. 13.—This was a sample of ginned cotton, and was clean, soft, lustrous, of cream colour and almost free from stains.

It was of fair strength, but irregular in length, varying from 1·4 to 2·1 in.; but mostly about 1·5 to 1·8 in. The diameter ranged from 0·0004 to 0·00075 in., with an average of 0·00056 in.

This cotton was valued at 1*s.* to 1*s.* 1*d.* per lb., on the same date as the hybrid cottons.

Native Buck Cotton

No. 14.—This was also a sample of ginned cotton. It was clean, harsh, fairly lustrous, of cream colour with a reddish-brown tint, and free from stains.

It was of good strength, and varied in length from 1·1 to 1·3 in., but was mostly from 1·1 to 1·2 in. The diameter ranged from 0·0006 to 0·00105 in., with an average of 0·00083 in.

This cotton was valued at 6*d.* per lb. with "middling" American at 5·32*d.* per lb.

Remarks

The hybrid cottons Nos. 1–12 were mostly of shorter staple and somewhat coarser than the sample of Sea Island

cotton (No. 13). They were, however, stronger than the latter, and the brokers stated that on account of their strength most of these cottons would be readily saleable at the prices quoted. It will be noticed that several samples, viz. Nos. 1, 5, 6, 8, and 11, were valued at higher prices than the Sea Island cotton No. 13; but that in no case was the value equal to that of "best Barbados" Sea Island cotton.

The Native Buck cotton was of good quality and was valued at 0·68*d.* per lb. above "middling" American.

It should be noticed that the samples were of small size, which rendered it difficult to ensure exact valuations, and the present estimates of their commercial value must only be regarded as approximate.

It is satisfactory to observe that the aim of obtaining a Buck × Sea Island hybrid yielding a cotton of long staple has been achieved, and it will be interesting to learn how the yields and hardiness of the hybrids compare with those of the indigenous Buck variety.

DIATOMITE FROM NOVA SCOTIA

A SAMPLE of diatomaceous earth from Nova Scotia was received at the Imperial Institute in April 1915. It consisted of earthy diatomite of a greyish tint. In addition to the diatoms a considerable proportion of clayey and fine sandy matter was present.

The material was analysed with the following results:

			Per cent.
Silica	SiO_2	soluble 42·88; insoluble 16·25	59·13
Alumina	Al_2O_3		10·32
Ferric oxide	Fe_2O_3		2·30
Lime	CaO		0·75
Magnesia	MgO		0·75
Potash	K_2O		0·35
Soda	Na_2O		0·04
Sulphuric anhydride	SO_3		0·28
Loss on ignition:			
Non-volatile organic matter		11·60	26·70
Moisture, volatile organic matter, and combined water		15·10	

The material was submitted to two firms of commercial experts who reported on it as follows:

(1) One firm stated that as regards its specific gravity the diatomite appeared to be of satisfactory quality, but that the grey colour was a great disadvantage, since a good white variety is usually required in the British market. They mentioned that a diatomite similar to the present sample is mined in Ireland and sold in Liverpool at only 38*s*. per ton, which would probably be too low a price to allow of export from Nova Scotia, especially as the freight charges would be based on the bulk and not on the weight of the consignments.

The firm added that if Nova Scotia produces a good white diatomite of similar specific gravity to the present sample there might be a possibility of marketing it in the United Kingdom.

(2) The second firm stated that the diatomite, as submitted, was in a crude state, and that although of good quality it would require preparation to make it of commercial value. They considered that after washing and calcining, the material would probably be worth about £5, or possibly even £6, per ton c.i.f. London (bags included); but they were of opinion that its importation in the crude condition would not be remunerative, in view of the fact that the freight charges on such material would be as high as on the refined product.

SPECIAL ARTICLE

THE WAR AND THE WORLD'S COTTON CROPS

By John A. Todd, B.L.,

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We have much to be proud of in the extraordinary recovery which British industries in general have made from the first staggering effects of the war, but there is some danger that in this mood of justifiable optimism we may lose sight of certain grave problems which will arise out of the

present conditions, when the war is over, if not sooner, and to meet which preparations must be made in advance. Of such problems, the position of the cotton trade with regard to the supply of its raw material is an outstanding case.

The question of the world's cotton supply has been critical since the beginning of the present century. Although the world's crops have nearly doubled in that period, the extraordinary expansion of demand has all the time been pressing harder upon the increased supplies. As the result of a careful collation of statistics from different sources, the writer has recently brought out the disconcerting fact that in five out of ten seasons before the war, the world's cotton consumption was actually in excess of the world's crops. The problem of an increased supply has therefore been exercising the minds of the cotton world, and has led to the formation, not only of the British Cotton Growing Association, but of similar associations in all other European countries which possess Colonies within the climatic possibilities of cotton growing. So far, however, it cannot be said that these pioneer efforts have got very far beyond the experimental stage. The total output of all the European Colonies in Africa (excluding Egypt) has not yet reached 100,000 bales of 500 lb. per annum, while the world's consumption is increasing, or would increase if the raw material were available, at the rate of something like 1,000,000 bales per annum. Prices have therefore risen to a very high level, as may be gathered from the following figures of quinquennial average prices of American Middling for the last twenty years:

1894–95 to 1898–99	3·76*d*
1899–1900 to 1903–04	5·44*d*.
1904–05 to 1908–09	5·78*d*.
1909–10 to 1913–14	7·16*d*.

During the season 1913–14 the price touched 7·96*d*., and until the outbreak of the war it had only fallen below 7*d*. for a very short time, the season's average being 7·26*d*. This high price, however, had its usual depressing effect upon the trade. The consumers were refusing to pay the high prices which the increased cost of raw material

demanded, and the boom of 1912–13 had clearly passed its highest point.

Under these conditions, the outbreak of the war threatened to produce an absolute *débâcle* in prices, especially as it happened to coincide with an American crop estimated at between 16,500,000 and 17,000,000 bales, or the largest on record. Prices fell steadily, until in December American Middling touched 4¼*d.*; but from that point a really marvellous recovery set in, which has now carried the price well above 6*d.*

The causes of this extraordinary recovery have been the subject of much discussion. Many of Lancashire's foreign markets have dropped out of the reckoning, but their places have been taken, for the time being at least, by a certain amount of new business obtained at the expense of the enemy, by the belated share of the cotton trade in the demand for war materials, and by the remarkable briskness of the home demand. There is, further, one important new factor in the consumption, namely, the demand for gun-cotton. Of the amount of this there is no statistical measurement possible, but it is stated that it may be well over a million bales per annum, and it is probable that this demand will increase.

The downward rush of prices in autumn 1914 resulted in a serious curtailment of the world's acreage under cotton this year. In Egypt the Government at once introduced a compulsory restriction of area, which, however, has since been modified. In India the restriction has been very serious. In West Africa the British Cotton Growing Association had to reduce the fixed price at which they buy seed-cotton from the natives. In America the level to which the price actually received by the planters fell—say, 7 cents per lb.—was notoriously below the cost of production. There is much difference of opinion as to what is now the minimum paying level of price for the average cotton planter, but it is certain that the cost of production has increased seriously in recent years, largely owing to the high labour cost, and that there is at least a considerable part of the crop which cannot be produced below 10 or 11 cents per lb. Now if any one could

guarantee that the present level of Liverpool prices (which means just about that price for the planter) would be maintained, the majority of the planters would probably continue growing cotton on at least a considerable portion of the old acreage. But if the war continues beyond the present year, as now seems certain, no one can tell what the effect will be on the demand for cotton, and we may have to face a renewed fall in prices, leading to a further reduction of acreage next year. On the other hand, if the demand remains at its present level, there may be a rise of prices this winter, though the war continues. The general consensus of opinion places the reduction of acreage in America this year at 15 per cent. This, with ordinary conditions, means a crop of 11,000,000 to 12,000,000 bales, and, allowing for a similar reduction in the rest of the world's crops, the world's supply in 1915-16, even with an unusually large balance carried forward from the 1914 crops, may not be enough to meet the demand.

But the most difficult question is what will happen when the war comes to an end, whenever that may be. There can be very little doubt that the world's stocks of cotton goods, which were probably high at the outbreak of the war, have been to a considerable extent worked off; and any revival of normal trade demand coming upon the reduced supply of raw material will almost certainly produce a more or less severe cotton famine. It is well known that the effect of the war has been to accentuate the process of substitution of cotton fabrics for other materials, especially linen and wool, in large classes of goods, and this change is likely to be permanent, for wherever cotton finds its way into a new trade it comes to stay. The home trade in cotton goods has therefore been on the whole very brisk, especially as, owing to the high wages earned in many trades, the workers have much more money to spend on clothing than usual. It is difficult to forecast what the conditions of demand will be when the war is over, but it is very probable that what is lost in the demand for war materials will be more than made up by the rush to replace the exhausted stocks of all kinds of other fabrics, and that, for a time at least, the demand will be above

rather than below normal. The longer the war lasts, especially if cotton prices remain fairly low, the greater will be the reduction of acreage, and the greater the danger of at least a temporary cotton famine, with consequent high prices for the raw material. At a time like the present, when everything seems to be forcing prices upwards, such a famine would be a very real disaster.

The probable degree of the scarcity will depend upon two things : (1) the time of the year at which peace comes, and (2) the willingness or otherwise of the American planter to return to cotton. Both of these questions are largely conditioned by the price factor. Should the price of cotton fall again during the coming winter, and peace be declared say in April or May of next year, *i.e.* after the crop is sown, the situation would be very serious. Cotton is a summer crop, and practically all the world's cotton fields lie in the northern hemisphere. The area sown in any year depends chiefly upon the price in the previous autumn and in spring. If, after the crop is sown, peace brought a revival of the demand, there would be no possibility of producing any increased supply until about eighteen months later, and in the meantime there is no saying to what level prices might go. It is not, of course, argued that there will be an actual shortage of cotton to the extent that cotton will be unobtainable. Supply will always meet demand *at a price*, because a high price will reduce the demand to the dimensions of the supply. The question is to what level would prices go under such conditions.

This again would affect the second question. There is no doubt that the American planters will go back to cotton if the price is high enough ; but there is as little doubt that the price which they will consider high enough will be much higher than Lancashire is willing to pay. There is no getting away from the fact that the situation of the American planter as regards the choice of crops, and also as regards his ability to hold out for what he considers a satisfactory price, has changed completely in the last few years, especially in Texas, from which the great bulk of the increased acreage in recent years has come. If the Southern

States are to revert to their maximum acreage, and go on increasing the area under cotton, they must get their own price, and that price is more likely to be round about 12 cents than 10.

We are therefore confronted with the possibility that if cotton is much below *7d.* between now and the end of the war, it may be much above it for a considerable time afterwards, and even more or less permanently. Should such conditions arise, Lancashire will again be faced with the problem of the supply of her raw material, and that perhaps in an even more aggravated form than it was in 1903-4, when Sully's corner, coming on the top of a short American crop, showed the danger of Lancashire being so largely dependent on America for the supply of her raw material.

Only one thing can be done to prepare the way for meeting this difficulty when it arises, namely, to arouse interest in the development of new cotton fields within the Empire, and the extension of existing areas, especially in India, Egypt, and the Sudan, where the work of the British Cotton Growing Association and the International Cotton Federation have already shown the way. Russia has shown her wisdom in developing cotton fields in Turkestan and Transcaucasia, which now supply the greater part of her large native consumption of cotton. Germany in her own sphere of influence in the Levant has, it must be admitted, produced large results. That is a point to be remembered in the inevitable rearrangement of the Turkish Empire after the war, as is also the fact that in Mesopotamia we have a potential cotton field, which will probably rival Egypt and the Sudan in quality as well as quantity. But the greatest possibilities for an immediate increase of our cotton supplies lie in India, where great improvements both in quality and quantity have been made in recent years.

It would be well if public interest in this question could be aroused now rather than later on. There is no question here, as in the dye industry, of foreign competition after the war rendering the investment unprofitable. In a land like India, where labour is plentiful and cheap, cotton growing will always be a profitable crop, if the natives

can be instructed and encouraged to produce cotton of the type that Lancashire wants. That India can produce such cotton is, in spite of the old Lancashire tradition, now beyond all question; but the natives will require a great deal of teaching—and Lancashire mill-owners and operatives perhaps not much less—and in many cases, both in India and elsewhere, the development of the crop will require large initial expenditure on irrigation works and railways. That such expenditure will be well repaid by results has been proved over and over again by experience in India, Egypt, and Africa. "You cannot build a railway in Africa that will not pay," said the President of the British Cotton Growing Association some time ago, and it is equally true of drainage and reclamation works in Egypt, or irrigation projects in India. Yet every corner of Africa shows railway schemes creeping forward by only a few miles per annum, for want of capital. The Egyptian Government have practically suspended their schemes of reclamation and irrigation, upon which depends a crop of say an additional million bales of cotton, and in India an irrigation scheme in Sind (the Rohri Canal project) which would mean an important extension of cotton cultivation has been "under consideration" for about fifty years (cf. this BULLETIN, 1915, **13**, 161).

It may be suggested that the hope of profit from such schemes might be frustrated by the revival and extension of the American crop under the impetus of higher prices; but the truth is that the possible expansion of the American crop is seriously hindered by two things, namely, boll weevil and the increasing labour cost; and the latter of itself is enough to turn the scale in favour of our Colonies. Cotton is a black man's crop, and it is now beyond question that the cost of production in America is much higher than in India, Egypt, or Africa. As long as the world's demand is unsatisfied, the trade must pay a price sufficient to tempt the American grower; and that price bids fair to be such as would pay India and Africa very handsomely. Even if the world's production should at some future date prove in excess of the consumption, leading to competition and a falling price, the British

cotton fields will be better able to bear the competition than America, because of their lower cost of production.

Every penny, therefore, that the British Empire invests now in cotton growing, either in education or in engineering, will be a profitable investment for the future, and the sooner the investment is made, the greater, as well as the quicker, will be the return. What we shall want after the war is not merely a British Cotton Growing Association with a capital of a paltry £500,000, but an organisation of the size of a State Department with all the combined resources of the British Empire behind it, and a capital of about as much as we are spending on this war in three days, say £10,000,000.

GENERAL ARTICLES

THE ECONOMIC RESOURCES OF THE GERMAN COLONIES

III. West African Colonies

In previous numbers of this Bulletin (1914, **12**, 580; 1915, **13**, 110, 233) an account has been given of the agricultural, forest, and mineral resources of German East Africa and German South-West Africa. In the present number it is proposed to deal with the German colonies in West Africa, viz. the Cameroons and Togoland. For the compilation of the part of this article dealing with agricultural and forest resources, which is largely based on information given in recent German Colonial Office reports, the Imperial Institute is much indebted to Mr. A. H. Kirby, B.Sc., Assistant Director of Agriculture, Southern Provinces, Nigeria.

CAMEROONS

The Cameroons was annexed by Germany in 1884, and its boundary was considerably extended at the expense of French Equatorial Africa in 1911 as a result of the Morocco Convention. Its present area is about 290,000 square miles, the greatest length from north to south being over 900 miles, and its greatest width over 650 miles. The native population in 1913 was estimated at about 2,650,000;

there were in that year 1,871 Europeans, of whom 1,643 were Germans.

The country is bounded on the north-west by Nigeria, on the north-east and east by the French possessions of the Military Territory of Chad and the Middle Congo, and on the south by the Middle Congo and the French possession of Gaboon. The frontier runs in a north-easterly direction from near Calabar in the Southern Provinces of Nigeria to Lake Chad and then in a general south-south-east direction to about lat. 2° N., from whence it strikes south-west by west, reaching the Atlantic just south of Spanish Guinea, which is thus surrounded on the north, east, and south by German territory. The general outline of the country thus described is broken in the middle east by a triangular piece of land which gives access to the Ubangi river, an affluent of the Congo, at Singa in lat. 3° 40′ N.; whilst in the south-east corner a strip of land 70 miles broad runs southwards, giving access to the Congo itself in about lat. 1° S.

The country on the whole is mountainous and forms the north-west limit of the central African plateau. In the west, opposite the island of Fernando Po and near the Nigerian frontier, the massif known as the Cameroon mountain rises, almost sheer up from the sea; the chief peak is Fako, the highest mountain in West Africa, with an altitude of 13,350 ft. From here a series of ranges runs almost parallel to the north-west frontier for a distance of about 250 miles, some of the peaks rising to nearly 9,000 ft. The elevated land then broadens out eastwards into a plateau 3,000 to 4,000 ft. high, which extends almost to the eastern frontier. Isolated mountain ranges continue along the north-western frontier to within 100 miles of Lake Chad, the highest peak here being the Vogel Spitz in the Shebshi mountains (6,500 ft.). North of the plateau the land falls rapidly into a plain which extends to Lake Chad, but to the south it is more elevated, having a general altitude of 1,500 to 2,500 ft.

Although well watered, the country had no access to any large river until the extension of its boundary in 1911, when outlets were obtained on the Ubangi and the Congo. The chief river rising on the north of the plateau is the

Lagone, an affluent of the Shari, a river which flows into Lake Chad. These two rivers form the north-east boundary of the Protectorate. The Benue also rises in the north of the plateau, but flows only for a comparatively short distance through German territory. To the south the chief rivers are the Sanaga and Njong, which flow into the Atlantic and the Ssanga, a tributary of the Niger. The Cross river rises on the western slopes of the mountains in the north-west, while flowing southwards from these into the Cameroon Gulf are the Mungo and Wuri rivers.

The chief towns on the coast, from north to south, are Victoria, Duala, the capital, Kribi, and Ukoko. Buea is a large town on the eastern slopes of the Cameroon mountain, and Edea is on the Sanaga about 40 miles from its mouth. In the mountainous region in the north-west are Bare, Dschang, Bali, Bamenda, Wum, Esu, and Kentu; to the east of these is Fumban, and to the west, in the low-lying country near the Nigerian border, Ossidinge. In the western portion of the plateau are Tibati, Banyo, and Tingere, and in the centre, at the junction of the main routes of the interior, is Ngaundere. In the country north of the plateau the chief towns are Garua, an important trading centre on the Benue, Lere, Binder, Marua, Mora, Dikoa, and Kusseri. In the southern part of the country are Yaunde, Dume, Bertua, Gasa, Carnot, Bania, Lomie, and Akoafim. Molundu is in the extreme south-east.

The internal communications are excellent on the whole. Good roads connect up most of the towns and three railways have been built, one from Bonaberi, near Duala, northwards to Nkongsamba, just south of Bare, another eastwards from Duala through Edea to Mbalmajo on the Njong, and a short one from Victoria round the eastern foot of the Cameroon mountain. The chief navigable waterways wholly within the Protectorate are the lower reaches of the Mungo, Wuri, and Sanaga, the Njong from near its source to Mbalmajo, and the Ssanga from Dume, near its source, for a distance of over 100 miles, and again from Nola to the Congo. Other navigable rivers to which the country has access are the Congo, Ubangi, Lagone, Shari, and the Benue (from Garua).

Climate

In the coast region of the Cameroons the climate is warm and moist, with a high rainfall. The temperature is not excessively high, the heat being tempered by the cold Benguela current coming northward from the Polar regions. According to Knox (*The Climate of Africa*, p. 193), February is the warmest month and July the coolest, the maximum and minimum temperatures being 89·7° F. and 66° F. respectively. The mean temperature at Victoria and Duala is about 77° F. This coast is one of the most unhealthy places in Africa, but the conditions are considerably better and more suited to Europeans in the high-lying districts in the north. The climate of the latter is largely of the continental type, characterised by extremes of temperature. At Bali the mean temperature is about 64° F., the maximum 87° to 90° F., and the minimum 43° to 45° F. At Fort Crampel, on the eastern side of the plateau, the maximum temperature reaches 113° F., and the minimum 49° F. On the Ngaundere plateau it is sometimes very cold, and sleet storms are not uncommon, the temperature sometimes falling to 37° F.

As regards rainfall, there are as a rule four more or less distinct seasons in the southern and central regions—the chief dry season at the beginning of the year, the so-called long wet season from June to September, a short dry season in October and November, and a short period of greater rainfall in part of November and in December.

The divisions indicated are by no means always well marked. During the year ending March 31, 1912, the weather in the whole colony was exceptional. Near the Cameroon mountain the rainy season set in especially early, and there was a good rainfall during the whole year, whilst in the south there was a reduced precipitation. The conditions in the next year, 1912–13, were generally normal, although the chief wet and dry seasons set in later than usual; an exceptional district with a proportionately small rainfall stretched from Victoria, northward past the Cameroon mountain through Ossidinge to Dschang, whilst within a zone in the south from Kampo-Kribi to

Akaofim the average rainfall of former years was somewhat exceeded.

The Adamaua district, situated on the north of the plateau, lies beyond the equatorial belt, and there are consequently only two seasons, one wet and one dry.

The western slopes of the Cameroon mountain have the highest rainfall in the country, the annual mean for a period of twelve years at Debunja, on the coast, being 412·23 in. At Victoria, to the south of the mountain, the mean annual rainfall is 171·27 in., and at Buea, on the eastern slopes, at an altitude of 3,215 ft., 105·71 in. Inland the rainfall is less, the mean at Yaunde being 60·76 in., whilst in the extreme north it is much lower. The two highest and two lowest precipitations in 1910, 1911, and 1912, with the names of the stations at which they occurred, were as follows (Idenau is on the coast to the west of the Cameroon mountain, and Rio del Rey a little to the north, near the mouth of the Cross river):

Period.	Number of stations.	Two highest precipitations. *inches.*	Name of station.	Two lowest precipitations. *inches.*	Name of station.
1910	9	286·9	Idenau	15·6	Binder
		146·7	Victoria	35·6	Kusseri
1911	9	406·3	Idenau	19·7	Binder
		200·2	Victoria	36·0	Kusseri
1912[1]	32	274·0	Idenau	13·4	Kusseri
		184·8	Rio del Rey	34·9	Garua

[1] *No returns for Binder in* 1912.

Agricultural Production

General

The chief product exported from the Cameroons is rubber; palm kernels, cocoa, and palm oil follow in order of value. In 1910 rubber formed more than one-half of the total value of the exports; in 1911, it had dropped in value, however, whilst that of the other products mentioned had increased. The preponderating importance to the country of these four products is shown by the fact that the proportion of their total value to the total value of the exports has been as follows: 1910, 95·6 per cent.; 1911, 93·8 per cent.; 1912, 93·2 per cent. The exports of rubber have fluctuated more than those of the other products because its exploitation is more directly dependent upon the stato

of the world's markets. The export of articles other than those mentioned, such as gum arabic, wood, and djavi, kola and shea nuts, although relatively small, show an upward progress which is considered to be hopeful for the future. The values per lb. of the chief products in recent years have been as follows:

	1909.	1910.	1911.
Plantation cocoa	4·6*d.*	4·9*d.*	5·1*d.*
Native-grown cocoa			3·8*d.*
Palm kernels	0·9*d.*	1·4*d.*	1·4*d.*
Palm oil	1·8*d.*	2·1*d.*	2·2*d.*
Plantation rubber	26·5*d.*	30·1*d.*	33·2*d.*
Wild rubber			19·9*d.*

The Cameroons may be said in a general way to present three chief agricultural areas: the southern, with rubber in increasing production; the middle provinces around the Cameroon river basin, with their plantations and areas rich in oil palms; and the grass country, northward, suited specially for cattle breeding.

Native Production

Rubber.—Nearly all the rubber exported has come from the native exploitation of wild plants; the chief of these is *Funtumia elastica*, in Yoko, Dengdeng, Dume, Lomie, and Molundu, whilst there is a much smaller export of the product obtained from species of Landolphia, especially *L. Dawei*, growing in the primeval forests and the savannahs, and exploited chiefly in the latter. Most of the rubber is bought by coloured middlemen who dispose of it to the mercantile firms; this method of trading has brought in an injurious system of credit. Evidence of the importance of rubber (besides that furnished by the exports) is available, which shows that in 1910–11 there were 49 firms in the trade, with 230 establishments at which it was bought and more than a thousand coloured middlemen; it was estimated in addition that about 25,000 carriers brought rubber to the coast and returned with trade goods; and finally, there is the fact that almost all the male population of Lomie, Molundu, Dume, and Dengdeng was concerned in rubber collection.

In 1911–12 almost all the production was in the forests of the south and south-east; it decreased considerably in the north-west, especially in Bamum, which brought

formerly a large yield: only 26,466 lb. came from there to Nssakang, the district export place on the Cross river, and the natural sources seem to be exhausted. It is recorded that there were rich districts immediately on the English boundary where the rubber had not yet been exploited. In the north, the rubber received through Garua was half as much again as in 1910–11; and it is stated that the quantity would have been still greater but for the circumstance that, on the Ngaundere plateau and the Ssari massif, whence the product is apparently sent to Garua, tapping had been only recently commenced. The comparatively small share of rubber plantations in the whole production is shown by the fact that, of a total export of 5,957,516 lb. in 1911, all except 23,912 lb. was from wild plants; whilst in 1912 cultivated plants accounted for only 53,040 lb. in a total shipment of 6,184,222 lb.

In the period 1912–13 the extension of tapping was favoured in all the chief districts of collection by a good dry season; and prices were somewhat higher than in the previous year, although there was a fall toward the end.

Oil Palm Products.—In common with other countries exporting quantities of oil palm products, the Cameroons owes the collection and preparation of these almost entirely to the primitive efforts of the natives. From 1908, when the exports of kernels were 11,737 tons, value £107,976, and of oil 2,983 tons, worth £48,388, there has been a steady increase in the shipments, except in the case of oil in 1910, when a diminution took place which is attributed to the taking of labour for the railway. In 1912 the increase of the exports of oil was greater than that for kernels; and this is explained by the diminution in the content of oil in the fruits in the previous season on account of the extended dry weather. Any "cultivation" by the natives is very simple in nature, consisting merely in the keeping of the stands clear of "bush." Efforts have been made to extend the use of machinery for cracking the nuts, in order to lessen the wastage resulting from the crude methods employed by the natives. Central establishments for the purpose existed in 1912 as follows: two in the Victoria district, a third in Maka (adjoining the

Northern Railway), and one at Mungo (Mpundo). No distinction for statistics can yet be drawn between the wild production and that from planted palms.

Ivory.—There has been a large decrease in the exports of ivory in recent years due in a great measure, apparently, to the exhaustion of the stores of ivory hoarded for many years by the natives, and to the extent of elephant shooting in the past ten years; the latter was diminished, however, toward 1911 by severe control through a Wild Animals Ordinance. The exports in 1910 amounted to 16 tons, valued at £124; in the following year there was a slight increase in the quantity, but the value of 1910 was not reached, owing to a fall in price: in 1910 the price per lb. of ivory at the coast was *7s. 4d.*; in 1911 it was *6s. 4d.* In the latter year the extension of the production in Adamaua became smaller, because of the prevention of trading northward over the French boundary owing to native risings in Wadai. In 1912 there was a large diminution in the export of ivory.

Other Products.—These are chiefly djavi nuts, shea nuts, kola, and gum arabic.

The exports of djavi nuts (*Mimusops Djave*) show a biennial fluctuation in conformity with their two-yearly chief production of crop; in 1912, however, the exports, chiefly from Duala, did not reach the quantity of the last year of maximum yield, namely 1910. The nuts are valued locally as food, and they appear to have been exploited to a greater extent in recent years, in the western districts from Ossidinge to Kribi.

The export of shea nuts takes place through Garua: there was a constant large decrease in the quantities until 1912, when it was 61·5 per cent. more than in the previous year.

In 1909–10 there was a large decrease in the export of kola because of bad crops near the coast. The exports through Garua diminished greatly in 1910–11, owing to the fact that a high export duty was placed upon kola in the previous year, so that much smuggling took place over the Adamaua border. A very good future for kola was predicted in 1912–13, and the striking increase in the exports of this product is attributed to the increasing demand

for it in Europe. An extension of collection has been taking place on the slopes of the Cameroon mountain and its northern neighbourhood; and there has also been increased planting both by Europeans and natives.

From an export of 267 tons in 1909 and 322 tons in 1910, gum arabic has continually decreased in production; chiefly, it is said, because of low prices. This was the staple product, second in value, from Adamaua.

Adamaua has also produced quantities, of one or two tons, of a so-called gutta-percha said to be obtained from species of Ficus; it has been hoped to increase the collection of this.

General Crops.—There has been comparatively little activity as regards the actual cultivation of crops by the natives, because of the natural richness of the country in products which enable them to buy what they want. The raising of food crops exists, however, for special demands, such as arise near railways, administrative stations, the larger towns, and the chief places on the caravan routes and rivers; near such places the native raises maize, plantains, bananas, cassava, sweet potatoes, and ground nuts, as well as sorghum (dura or dari) in the northern districts, and some kola and sesame in isolated places. In several districts a certain amount of tobacco is planted; there is also some little fruit raising, notably in the villages of Ambam. In the highlands of Dschang, and in other places such as Ebelowe and Yaunde, new crops such as the English potato, "black bush" beans and turnips have been introduced; the climate seems to be suited to these crops.

Numerous inhabitants of the district of Duala have in recent years laid out farms on the banks of the rivers Mungo, Wuri, Dibamba, and Dibomba, where they grow cassava, plantains, maize, yams, and other products; the activity in this direction is said to have been actually so great as to lead to a diminution of the once lucrative intermediate trade in which foodstuffs figured largely. A similar condition exists in Edea. In the grass lands, the chief food plants are millets and the sweet potato, which are produced already in quantities greater than those needed to supply the local demands.

It appears that the results of attempts to induce the natives to take up new cultivations depend on the presence or absence in their district of wild plants that they can exploit. Whilst, for example, the inhabitant of the Lomie district, who still knows of rich stands of wild rubber plants, is hardly to be incited to commence rubber cultivation, it has been experienced in Kribi, where these do not exist, that the distributions of young plants are very readily taken up and that these are carefully planted. It is recorded, however, that oil palm cultivation has been introduced with some success to the natives in the district of Lomie, just mentioned, as well as to those in Yaunde, which also produces rubber.

The hoe is almost exclusively the implement of native cultivation. It seems that the soils in the greater part of Cameroons are not rich in mineral plant food, so that constant rotation without manure is impossible and intermittent fallowing is necessary.

Cocoa.—The chief districts for native cocoa cultivation are the low-lying country of the Mungo, Wuri, and Sanaga rivers, the districts of Duala, Yabassi, and Edea, near these rivers, and parts of the slopes of the Cameroon mountain. It has extended in all these areas, except in the last-mentioned, where pests and the taking up of the land for European plantations have prevented an increase of planting. The greatest success is in Yabassi, where the conditions of climate and soil are most favourable. The part taken by native, or trade cocoa in the exports is moderate: 475 tons in 1910, 645 tons in 1911, and 701 tons in 1912.

The native cocoa is, for the greater part, simply dried over a fire, without any attempt at proper fermentation.

Other Native Cultivation.—This has been concerned mainly with the oil palm and rubber; and although there has been some encouragement by the provision of planting material and advice, very little progress seems to have been made. Cotton is grown simply for the native needs; its cultivation has been recently the subject of experiment by the administration in apparently suitable districts in Bamum and Adamaua.

European Agricultural Production

General.—The statistics given in the following table enable some idea to be formed of the progress which has been made in recent years in European plantations; but it should be mentioned that the details of the areas are incomplete, because of the difficulty in obtaining correct figures for the totals, arising from the existence of intermediate and mixed cultivations, and from incomplete returns:

	On Jan. 1, 1909.	On Jan. 1, 1910.	On Jan. 1, 1911.	On Jan. 1, 1912.	On Jan. 1, 1913.
Total area of plantation land	205,765[1]	208,245[1]	237,833[1]	248,898[1]	—
Area actually planted	28,265[1]	31,978[1]	37,810[1]	54,490[1]	70,563[1]
Europeans on plantation staffs	104	110	124	147	195
Native labourers	8,159	9,380	10,415	13,272	17,827
Plantation area cultivated in:					
Cocoa	18,945[1]	21,023[1]	23,958[1]	26,635[1]	32,903[1]
Funtumia	6,668[1]	7,515[1]	10,475[1]	10,550[1]	Decrease
Hevea	673[1]	988[1]	5,473[1]	7,010[1]	8,973[1]
Oil palms	124,800[2]	109,400[2]	2,388[1]	4,790[1]	Increase
Bananas (for food) / Plantains (meal bananas)	240,000[2]	409,000[2]	1,788[1]	4,493[1]	5,410[1]

[1] *Acres.* [2] *Plants.*

The remaining areas, not specified for any particular cultivation, are occupied chiefly by coffee, kola, cassava, Ficus, rubber vines, Furcræa, and tobacco.

Abnormal conditions of weather in 1911–12 affected the yield from the plantations; for example, in Victoria, the chief product, cocoa, lost 30 per cent. on the production of the previous year. The circumstances, nevertheless, did not prevent the making of new plantations and the extension of those existing. In 1912–13 the weather was most favourable, for new planting, on the slopes and in the neighbourhood of the Cameroon mountain, which appear especially suitable for the raising of products in plantations.

Cocoa.—The areas in bearing have been as follows: 1909, 13,328; 1910, 15,290; 1911, 17,560; 1912, 20,438 acres. A comparison of the figures given already for the native production of cocoa with those of the total exports presented at the end of this article, will serve to show the preponderating share of plantation cocoa in the total prouc tion. The large increase of exports in 1912 is attributed to the very favourable weather in that year. It is

stated that more care, with artificial manuring, is wanted in the cultivation, and that the chief diseases and pests of cocoa, such as brown rot, "cockchafer grubs," and "bark bugs," are not under control. Nevertheless, the future for cocoa seems good.

Rubber.—The interest in Funtumia for plantations has gradually decreased, and as no means have been found for increasing its yield of latex, its abandonment in cultivation is only a question of time; no new plantings were recently completed, and the existing ones were being destroyed as they became exhausted.

On the other hand, there has been increased activity regarding Hevea, which is considered to demand less from the soil than Funtumia, and to be more suited for planting with cocoa. The extension of Hevea has suffered from the lack of seed and other planting material, and through the sowing of seed in abnormally wet weather; seed has been obtained from the East for planting, but more recently part of the supply has been possible from trees coming into bearing in the country itself. The first tapping of Hevea took place in one plantation in the season 1912–13.

As has been mentioned previously, the exports of plantation rubber are comparatively small. These have been: 1909, 5,922 lb.; 1910, 5,795 lb.; 1911, 23,912 lb.; 1912, 53,040 lb. Both Funtumia and Hevea are stated to suffer from an unspecified root disease, and Funtumia from "stag beetles" in addition.

Oil Palm.—Interest in the oil palm for plantations has been increased by the successful introduction of machinery for the preparation of its products. The plantation area of the palm in bearing was reckoned in 1912 at 4,118 acres. The prospects of the cultivation were considered favourable, especially in view of the almost unlimited market for vegetable oils and fats.

Tobacco.—Attempts were made in 1911 to encourage tobacco-planting in the German colonies by the guarantee of a definite price for quantities of at least 100 cwts. raised and prepared in those colonies. The planted area in plantations in the Cameroons increased from 50 acres in 1911 to 383 in 1912; 230 acres of the latter had yielded a crop.

In view of the expensive nature of the cultivation, it was hoped that Cameroons leaf for wrappers would gain a good market. The prospects of tobacco seemed to be good.

Coffee.—In 1911 there were only 25 acres under coffee. Since that time there has been some increase of planting through the importation of seed of *Coffea robusta* from Java; but the results so far obtained do not indicate any great future for coffee in the country.

Bananas and Plantains ("meal bananas").—These have been planted in increasing quantities for labourers' food, and attempts have been made to establish an export trade in fresh bananas and dried plaintains. In 1911 the exports reached their first extensive increase, partly on account of experimental shipments, the dried plantains being made into meal in Europe; the increase in the case of dried plantains, which had by far the greatest share in the export, was so quick that in one quarter alone of the year 1911 about 200 tons were shipped. The planters provided the necessary drying equipment, and as no special capital outlay was required for this, whilst this branch of industry appeared to form a useful secondary source of income in plantations having one chief crop, a large extension of the production of fresh and dried plantains was expected. The expectation was not realised, however, as in the next year, 1912, shipments fell to less than one-half, because the market for the fresh and dried plantains was not capable, apparently, of such extension as was at first imagined; whilst the experimental shipments of bananas, begun in 1911 to test the possibility of transport to Europe, ceased. It is thought that the provision of steamers suitable for the transport of fresh bananas would soon bring capital sufficient for providing a regular export of the fruit.

Animal Production

As in the other German colonies, much attention has been paid to stock-breeding in the Cameroons, in spite of the very great difficulties caused by the tsetse fly.

Anything in the nature of methodical horse-breeding by the natives exists only in Kusseri, in the extreme north, and in Garua in Adamaua. Horses are also kept by the

natives chiefly in Banyo, Bamenda, and Yoko, in the middle of the country; but, it is stated, in a condition of absolute negligence. Nothing has been done by the natives for the extension of horse-breeding; but both this and cattle-breeding have been matters of increasing concern on the part of the Government (*see* this BULLETIN, 1913, **11**, 470).

The indigenous cattle are of two kinds, namely the dwarf (so-called woodland cattle) and the humped cattle, of which again different races exist. Cattle-breeding in the proper sense is only found among the natives in Adamaua, Banyo, and the Lake Chad regions; from these places there was once an active export of cattle to the neighbouring British and French Protectorates; but this has diminished in recent years owing to a large export duty. The interest in cattle-production on the part of the natives has been increased of late in other districts, notably in Dschang (Djuttitsa) and Bamenda, through the efforts of the Government (*loc. cit.*).

The supply of meat for the coast towns, Duala, Victoria, and Buea, has been filled for the greater part by cattle from Banyo. The increased prosperity of the rubber districts of the south, especially Molundu, Dume, and Lomie, has led in recent years to a demand for meat among the natives, and a regular trade in stock has sprung up in Adamaua, conducted by the Hausa and Fulani; in 1911 about 20,000 head of large stock and 8,000 of small stock were sent from Adamaua to the south, and this is estimated to mean an exchange between the north and the south to the value of about £150,000. The trader in stock has thus been enabled to buy European wares to an important extent, so that the market in Garua, the chief trading place on the Benue river, has become controlled largely by such goods coming from the south, and (it is stated) trade in this direction has been superseding trade by the Niger-Benue route. One result of this has been a serious depletion of small stock in the north, especially in the district of Bamum, leading to a proposal to limit the purchase of animals for a time.

As is usual in West Africa, the natives possess neglected goats, sheep, and fowls, and in some cases pigs,

though this is only true to a very small extent in the southern districts.

Of diseases of stock, trypanosomiasis is found according to expectation in the humped cattle, also in horses, mules, and sheep, and piroplasmosis in horses (Duala). Cattle in Garua and Banyo especially suffer much from lung-sickness, which is stated to be continually reintroduced by the traffic in the animals; another disease, which is constantly introduced afresh into Adamaua and Banyo, is foot-and-mouth disease; repeated measures for the prohibition of the movement of stock, directed against the former of these diseases, has caused some interference in trade. From Edea losses through *Trypanosoma vivax* have been reported. Cattle in Banyo have been threatened with loss from contagious pneumonia, said to come from the neighbouring British Protectorate and to be controlled by the rigorous prohibition of imports of animals.

Besides trypanosomiasis and piroplasmosis, mentioned already, the chief diseases of horses appear to be a peculiar epizootic lymphangitis designated as African glanders, and influenza (Garua). No very serious diseases seem to exist among small stock; although there are local losses from lung worms, and in parts of the south a deadly disease, of which nothing useful is known, occurs among pigs.

In common with the greater part of tropical Africa, the Cameroons has its greatest enemy to stock in the tsetse fly.

Forestry

The chief planting activity appears to have been at Johann-Albrechts-Höhe, and in the Dibombari district (oil palm cultivation) on the Northern Railway; a forestry plantation at Manoka, near Duala, was abandoned on account of its remoteness, the difficulty of water supply, and the constant lack of labour. The principal work for the making of forest and state reserves has been conducted in Yabassi, Yaunde, Edea, and Dschang.

The efforts of the forest department and of private persons have been concerned mainly with: investigations of woods suitable for beams, wharves, and for boat and wagon building; trials of woods resistant to *Teredo navalis*,

for small boats; and experimental shipments to German South West Africa of woods serviceable for building, mining, and street paving.

A large increase, amounting to 270 per cent., in the production of building and other timber took place in 1911. The first place in the exports is held by Cameroons mahogany, which is stated to be increasing gradually in value in the market; its export in 1912 was about 8,000 tons, worth over £22,000, the value in 1910 having been £7,022. The wood of importance after mahogany is Cameroons ebony; exports have been as follows: 1909, 672 tons worth £3,038; 1910, 1,221 tons worth £6,090; 1911, 1,652 tons worth £6,777; whilst in 1912 the value of the shipment was £9,055.

The increase of exports has been largely due to an increase of cutting by the natives, and this has entailed a considerable amount of robbery by them. As a consequence, timber exploitation on Government lands was entirely prohibited to natives in the period 1912–13, and concessions were given to Europeans with much caution; a decrease in the production was therefore expected. A difficulty regarding the exploitation of timber in the Cameroons is the lack of good waterways in the forest regions.

Among minor forest products, silk-cotton from *Bombax buonopozense* has been valued favourably; kapok (*Eriodendron anfractuosum*) also occurs.

Mineral Resources

No useful mineral deposits that could be made the basis of a mining industry have as yet been proved to exist in the Cameroons; but a large part of the Protectorate is unexplored. Cretaceous and Tertiary rocks occur in the coastal area and extend northward to the Nigerian border. Gneisses and schists of pre-Cambrian age, with intrusive granites, extend over wide areas in the hinterland. Volcanic rocks of supposed Tertiary age are very abundant. The Cameroon mountain is built of basalt, which is the prevailing type of volcanic rock.

Pegmatites and quartz veins are associated with granitic intrusions in the pre-Cambrian rocks. These carry tourmaline in the region north of Duala, as in the Dschang

district. Quartz veins with small amounts of pyrite and arsenopyrite also occur.

Tinstone occurs in pegmatite veins in Nigeria, and may be expected to be found also in the Cameroons; but though prospecting has been carried on in various parts of the region bordering on Nigeria, for the purpose of finding tinstone and wolframite, the results have so far been negative. Moreover, no gold has been found, excepting an occurrence of spangles of gold of theoretical interest only, in a dyke rock (a bostonite) on the eastern boundary of the Ossidinge district.

Promising occurrences of mica have been found in the pegmatites of the Ossidinge and Kentu districts.

Galena is found in Cretaceous sandstone in the Ossidinge district; but hitherto no argentiferous lead-zinc ores comparable to those of Nigeria have been found.

Iron ores, some of which are manganiferous, occur abundantly in the Cameroons. Many of these are of the lateritic type, and furnish material for native smelting, as in other parts of western Africa. In some localities, iron ore has been formed by the decomposition of basalt. Masses of red and brown iron ores of this type are found on hill-slopes in the neighbourhood of Bali and Bamenda. A sample of this ore was found to contain 42·25 per cent. of metallic iron, 0·35 of manganese, 0·17 of phosphorus, and 12·26 of silica. Richer ores, of the magnetite type (magnetic iron ore) are found among the pre-Cambrian gneisses.

Bauxite, of value as aluminium ore, may occur among the lateritic weathering products of the Cameroons; and the abundance of water in the hilly country may furnish a cheap source of electrical energy for smelting purposes.

Clays and loams suitable for brick-making are abundant in the Cameroons. Limestones, however, are scarce, and those so far discovered are not of suitable quality either for cement-making, or for fluxing purposes in smelting iron ore.

Indications of the presence of petroleum have been reported in the neighbourhood of Duala, near the coast; but borings made in this neighbourhood had negative results. Occurrences of asphalt are reported at Ossidinge

and Mamfe on the Cross river. A thin layer of coal yielding 48·3 per cent. of ash occurs at Mamfe. These occurrences are of no value in themselves, but they are indications that may prove to be worth following up by further work in order to ascertain whether there is a possibility of finding useful deposits of coal and oil.

Salt springs occur in the Ossidinge district, and are of some local importance, as salt is a scarce commodity in districts far removed from the coast. Samples of brine from these springs yielded from 5 to 8 per cent. of sodium chloride. Such a strong brine may perhaps be taken to indicate that salt beds may occur beneath the surface in this district.

As a whole the country shows promising indications of the existence of a number of economic minerals, which justify, at any rate, more systematic exploration.

Exports

The following table shows the quantity and value of the chief exports from the Cameroons during 1911 and 1912, together with the chief countries of destination in 1912:

Product.	1911.		1912.		Chief countries of destination in 1912.
	Tons.	£	Tons.	£	
Bananas, fresh and dried, and banana meal	226	4,855	104	880	All to Germany.
Cocoa	3,525	165,368	4,479	212,114	Germany and United Kingdom.
Kola nuts	87	953	235	8,348	Germany and neighbouring countries in Africa.
Palm kernels	14,937	208,393	15,742	220,308	Germany and United Kingdom.
Palm oil	3,333	71,215	3,537	81,119	United Kingdom and Germany.
Djavi nuts	45	254	189	1,258	Germany.
Ground nuts	2	22	10	64	All to Germany.
Shea nuts and shea butter	65	232	105	645	United Kingdom and Germany.
Wood	7,089	19,409	11,109	34,793	Germany and United Kingdom.
Rubber	2,664	551,513	2,766	573,611	Germany and United Kingdom.
Gum arabic	259	2,135	221	2,218	All to United Kingdom.
Live animals	—	114	—	1,274	Neighbouring countries in Africa.
Ivory	40	29,038	34	26,810	Germany and United Kingdom.
TOTAL EXPORTS	—	1,062,544	—	1,166,811	——
TOTAL TRADE (imports and exports)	—	2,528,420	—	2,878,890	——

TOGOLAND

The protectorate of Togoland, annexed by Germany in 1884, consists of a narrow strip of country bordering on the Gulf of Guinea and bounded on the west by the Gold Coast Colony, on the east by Dahomey, and on the north by Upper Senegal and Niger, the two last-named being French possessions. The coast line extends for only 32 miles, but the country broadens to about 150 miles in the interior, narrowing again in the extreme north to about 70 miles. The distance from the coast to the northern boundary is about 340 miles. The country has an area of 33,660 square miles, and is somewhat smaller than Sierra Leone or Natal. The native population in 1913 was estimated at 1,030,000, and in that year there were 368 Europeans in the country, of whom 320 were Germans.

The coast, which is low and sandy, runs in an almost straight line, and is backed by a series of lagoons, the largest of which is known as the Togo lake. A range of mountains traverses the country from the south-west to the north-east, reaching its greatest altitude in the south, where the mountains of Tarakuse (3,310 ft.), Dabo (3,130 ft.), and Moltke (2,700 ft.) occur. The highest peak in the country is Mt. Agu (3,360 ft.), situated in the south, just east of the main range. In the north the range reaches its greatest height in Ssosi-Bo (2,980 ft.). The general elevation of the range is from 2,000 to 2,500 ft. In the north it broadens eastwards into a plateau with an elevation of about 1,000 ft., but in the south it has a fairly continuous escarpment towards the east. To the west of the range is a tableland seldom reaching 800 ft., through which the chief river of the country, the Oti, flows from the extreme north-east to its confluence with the Volta. The latter river for some distance forms the western boundary of the country, but its lower course is entirely within the Gold Coast Colony. The chief river in the east is the Monu, which rises in the mountain range near Ssosi-Bo and flows entirely through German territory, except for a distance of some 35 miles from the coast, where it forms the eastern boundary of the country. Two smaller rivers,

the Sio and Haho, rise in the southern part of the range and flow into Togo lake.

The capital, Lome, with a population of about 6,000, is situated on the coast, almost on the western frontier. It is the only recognised port of entry, and possesses an iron pier about 400 yards long. Other important towns on the coast are Anecho, the old capital, Bagida, Porto Seguro, and Kpeme. Of inland towns the chief are Tsewië, 21 miles north of Lome, Nuatja, 35 miles further north, Atakpame, another 40 miles north, Misahöhe, on the mountain range 72 miles north-west of Lome, Kete-Kratschi, on the Volta river, an equal distance north-west of Misahöhe, Bismarckburg, in the mountains, about 90 miles north of the latter town, and Sakode and Bassari, 65 and 75 miles respectively further north. Yendi, about 50 miles west of the last-mentioned town and 15 miles from the Gold Coast frontier, and Sansane-Mangu, on the Oti river in the extreme north, are important towns on the main caravan route between Ashanti and the French Niger districts.

Lome and Anecho are connected with the chief inland towns by good roads, some of which are metalled in places, drained, bridged, and carefully constructed. In addition there are good roads linking up the inland towns, especially in the southern part of the country. Three railways have their termini at Lome: one runs to Anecho (27 miles), another to Atakpame (100 miles), and the third to Palime, a few miles south-east of Misahöhe (74 miles).

Climate

The climate on the coast is hot, humid, and unhealthy. Malaria is prevalent, and black-water fever not uncommon in the country, whilst a serious outbreak of yellow fever occurred at Anecho some years ago, resulting in the death of several Europeans and necessitating the removal of the government to Lome. Inland it is cool during July and August owing to the southerly and south-westerly winds which prevail, whilst it is warmest and driest in January to March owing to the winds from the north. The harmattan blows during December and the first half of January, and in the coast regions takes the form of a dry, dust-laden wind.

The mean annual temperature on the coast is 78·8° F., and in the interior 73·4° F. At Bismarckburg, situated at an altitude of 2,330 ft., the mean annual temperature is 76·8° F., the mean maximum being 85·3° F., and the mean minimum 70·7° F. At Misahöhe, at an elevation of 1,929 ft., the mean annual temperature is 75° F., while at Kpeme, on the coast, it is 80° F., the mean maximum and minimum temperatures at the latter place being 89·2° F. and 70·8° F. respectively.

Togoland naturally participates in the distribution of rainfall that obtains broadly in the parts of West Africa bordering on the Gulf of Guinea; this has been described above for the Cameroons. In recent years, however, the conditions of the precipitation have been abnormal, for an unusually heavy rainfall in part of the season 1910–11 was followed by partial drought in 1911–12 and a general and serious want of rain in 1912–13.

In the first of these periods, the rainfall in June and July was very large in comparison with that of former years, so that there were several inundations and washouts on the railway, whilst the lagoon at Anecho broke through to the sea temporarily, between that place and Adjido. The period 1911–12 brought a generally normal precipitation, although in the southern districts a heavy rainfall at the beginning was followed by dry conditions, so that the two rainy seasons, even, showed a remarkably small precipitation.

The year 1912 is said to have been very dry. In the hilly land lying between the coast and the mountainous districts, where there are usually good rains, the conditions were virtually the same as those in the generally drier lowlands of the river Oti (a tributary of the Volta), and in both cases the weather was abnormally dry. In the districts comprising the mountainous regions and the neighbouring spurs, regarded as the most important part of the country in an agricultural sense, and generally considered favourable in the matter of rainfall, there was a precipitation much lower than ordinary.

The fact that such circumstances arise shows the need for the diversification of crops and for the conservation or replacement of the natural forest cover of the country.

Native Agricultural Production

Oil Palm Products.—These, with maize and rubber, and cocoa, which has been showing increasing production, are the exports of most value. The exports of oil palm products have increased steadily since 1905, and in 1911 there was a sudden leap in the production, due chiefly to the favourable conditions of weather, the opening up of the country by railways, the creation of new possibilities of development in Atakpame, and the extended activity of the native through the partial failure of the maize crop. Most of these causes operated chiefly in Misahöhe and Lome. The want of rain in 1912 brought the exports below those of the record year, 1911; but the reduction through the lessened crop was almost made up by greater exploitation.

The exploitation of the oil palm has been encouraged largely by the introduction of machinery for preparing the products, especially in the Misahöhe district, Lome, and the Anecho district.

Maize.—The very heavy rainfall in part of 1910, mentioned already, reduced the export in this year to one-seventh of what it had been in 1908; there was in the same way a great scarcity of this chief food of the natives, to which a lessened activity on their part contributed, because of an outbreak of smallpox in Anecho. In the next year the production was reduced chiefly through want of rain, and it again received interference through the prevalence of smallpox in the coast districts; the prices in the country became about ten times the normal. The year 1912 saw similar adverse conditions, with a still larger increase of local prices, so that finally foreign maize was imported. In spite of all this, the export of maize has still continued.

Rubber.—Nearly all the rubber has been collected in the districts of Misahöhe, Atakpame, and Kete-Kratschi, where it is brought in, prepared, and then bought from the natives by negro middlemen and sold to the European trading firms. Two kinds are exported: the more valuable from *Landolphia owariensis*, which comes on the market in the form of balls (the so-called "Adele balls"), and the less valuable "Sayi rubber" (from the latex of *Ficus Vogelii*

and various vines), known as "Togo lumps." The exports of rubber increased steadily up to 1912, but there was a considerable decline in 1913.

Cocoa.—The cultivation of cocoa is almost exclusively confined to the Misahöhe district, where it was introduced by the natives themselves through the success of this crop that they had witnessed or heard of in the neighbouring Gold Coast Colony. In 1903 the exports were 1,907 lb., worth £42; in 1913 they had risen to 330 tons, valued at £16,660. The deep alluvial soils of the Buëm district of Misahöhe afford the best conditions for cocoa, and every farmer has a number of trees, or at least a few young plants, growing on the banks of the streams near his fields. In recent years cocoa cultivation has received the encouragement of the Government, in districts suited to it, with precautions at the same time against injurious deforestation and attention to means for the control of pests.

Cotton.—Special efforts have been put forth by the Government for the encouragement and improvement of cotton growing (*see* this BULLETIN, 1913, **11**, 475). A decreased production in 1910–11, caused by unfavourable conditions of weather and the large production of food-stuffs in Atakpame for railway labourers, was more than made up in 1911–12, when there was a large increase in the last-mentioned place and in Anecho, although the rainfall in the latter district was by no means good. In Sokode the development was hindered at first through want of railway communication; at this place, *Gossypium neglectum* was planted through the agency of the chiefs, acting under the direction of the Government. Here, as well as in the other northern districts of Mangu and Yendi, the attempts to make cotton a staple product failed, even after the extension of the railway beyond Atakpame, not only because of the unfavourable seasons, but (it is stated) on account of the deterioration of the species (*G. neglectum*) tried in those places. In 1912–13 there was still good progress in Atakpame, Lome, and Anecho; Misahöhe seems to have proved a failure as a district for cotton, chiefly on account of the continually increasing interest in cocoa and the oil palm.

In the southern and middle districts, with the exception of the coast region, the cotton grown has been "Togo-Sea-Island," the seed being provided from Ho in the south-west; cotton raised from this seed has shown itself to be especially suited to the districts of Sagada, Atakpame, and Nuatja. The ginning percentage of the 1912 crop grown at Sagada and Nuatja is stated to have been 32 to 33·7, and 35 to 36·4 respectively. This cotton has received good reports from the Bremen Cotton Exchange, in respect of the three qualities length, strength, and appearance.

The amount of cotton seed distributed to the natives was about 7,200 loads of 60 lb. in 1911–12, and 7,850 loads in 1912–13. Good prices for cotton seed have led to an increased export.

Coconut Palm.—The exports of copra at present are only small. There has, however, been a continual steady extension of the area planted with the palm in recent years; although, especially in Lome, serious loss has been caused through drought, and a rhinoceros beetle causes a general loss in young plantations. It is stated that a considerable number of the more wealthy natives have become owners of coconut plantations, and have thus laid the foundations of a sound prosperity. Of the 186 and 160 tons of copra exported in 1911 and 1912 respectively, 124 and 134 tons came from the plantation of Kpeme, owned and managed by Europeans.

The reduced export of copra in 1912 is attributed to drought and the increased price of foodstuffs. The exports give little indication of the total production, as large numbers of nuts are used for food.

Ground Nuts.—These form the most important product of the regions of the hinterland, and the exports have been almost exclusively in the direction of the neighbouring countries: for example, these took 127 tons of a total export of 129 tons in 1911. Although the unfavourable conditions and an increased inland consumption caused a large reduction of the exports in 1912, it is considered that the districts near the railway can be made to produce quantities that should bring the ground nut into the front rank among articles of shipment.

Kapok.—This product has received special attention from the Government, especially in the districts of the hinterland; its recently increasing uses, good prices, the ease with which the tree can be cultivated, and the good quality of the product from Togoland are all adduced in favour of its extension. Both the white and the common grey kapoks are collected, the former being regarded by experts as equal to the best Java kapok. Seed has been distributed among the natives in large quantities, especially in the districts of Sokode-Bassari, Kete-Kratschi, and Mangu. Attempts to gin the product by machinery have not yet given satisfactory results.

Other Products.—The remaining articles of native production are chiefly shea nuts and butter, cassava, yams, sweet potatoes, coffee, kola, taro, rice, Sorghum, Pennisetum, peppers, beans, and tobacco. The reason for the large decrease in the exports of shea products is the much reduced internal transit trade, which brings them to the coast, owing to the drought and smallpox. The bad maize crops have caused the extension of cassava planting in the coast districts; there is an increased production of a cassava meal, of good keeping qualities, called "Galli"; virtually all the cassava products are exported over the inland boundaries. There is a native cultivation of coffee in some of the hill districts of Misahöhe, but it is not considered to be capable of much extension, and coffee does not appear among the exports. Though the shipments of kola are trivial, there has been a rapid increase of production. Only some of the other products mentioned are exported, and that simply into neighbouring countries.

Good reports were received on shipments of the seed of *Strophanthus hispidus*, which was valued at 67*s.* to 73*s.* per lb., and there was said to be a good future for the product, but this view seems to be unduly optimistic.

European Agricultural Production

There have been three European planting undertakings, possessing land chiefly in the province of Gadja, in the Misahöhe district. In 1911 they possessed 27,150 acres, of which 2,478 were cultivated; in 1912 the cultivated area

increased to 2,968 acres, and two new plantations were added, one in Misahöhe of 3,375 acres, chiefly cocoa, and one in Anecho, about 875 acres, in oil palms (a small oil palm plantation has existed in Anecho for some time). The chief plants grown are the coconut palm, Sisal hemp, cocoa, and oil palms. As has been indicated, most of the copra exported comes from one of these companies, which also exported Sisal hemp for the first time in 1911.

Animal Production

Lome, Anecho, and Misahöhe are the chief places for cattle, but there is nowhere any methodical breeding of animals by the natives. In the northern regions cattle suffer seriously from lung sickness and splenetic fever, as well as from worms, and development is greatly hindered; the loss is specially severe in Sokode. In these hinterland regions there is some horse-breeding, in spite of tsetse fly; mules have been introduced successfully into Sokode, and have proved as useful and as resistant to disease as the native horses. On the coast, horses are rare.

There is an increasing interest in pig production. The export of small stock has increased because, in consequence of the partial failure of maize, the native sold his stock to the trader to get money to buy food. In recent years the values of exports of animals have been as follows:

	1909.	1910.	1911.	1912.
	£	£	£	£
Cattle . .	8,527	6,248	—	24,784
Small stock .	3,219	4,680	5,062	5,081
Poultry . .	289	201	186	—

Forestry

Forestry work is stated to have suffered from the want of staff; it has been carried out chiefly in Haho-Baloë, Mo-Kamaa, Sansane-Mangu, Kolangaschi, Yendi, Atakpame, and Sokode. In 1911-12 an addition of 548 acres at Haho-Baloë brought the whole afforestation area there up to 1,235 acres. In Sansane-Mangu, Kolangaschi, and Yendi there were planted respectively 1,050, 750, and 143 acres in that year; in Atakpame the existing timber reserve was

increased to 9,500 trees, and in Sokode 63 acres were planted with kapok; whilst only clearing for new cultivations was done in Mo-Kamaa. In Haho-Baloë in 1912–13 the cultivated area had reached 2,250 acres; the severe and sustained drought in this period caused much loss of young plants, which was aggravated by bush fires and damage from vermin and the larvæ of insects.

Other work consisted in unsuccessful shipments of the resin of *Daniella thurifera*, trials of wood for stoking on the railway, the supply of wood for burning for power at the wireless telegraphy station, and the investigation of useful soft woods at Lome. The lack of mechanical means for cutting timber prevents competition with imported woods. Attention is stated to be required to the threatened exhaustion of the existing stands of wild rubber.

The following woods are stated to be capable of exploitation; *Diospyros mespiliformis*, *Erythrophlœum guineense*, *Chlorophora excelsa*, *Afzelia africana*, *Anogeissus leiocarpus*, *Pseudocedrela Kotschyi*, and *Pterocarpus erinaceus*. Timbers tried as untreated sleepers for the Lome-Atakpame railway were still good in the following proportions after twenty-three months of exposure: *Prosopis oblonga*, 88 per cent.; *Syzigium guineense*, 80 per cent.; *Mimusops multinervis*, 72 per cent.; *Cassia Sieberiana*, 64 per cent.; *Chlorophora excelsa*, 60 per cent.; *Cynometra megalophylla*, 28 per cent.; *Uapaca togoensis*, 12 per cent.

Mineral Resources

The geological features of Togoland exhibit a roughly longitudinal arrangement. A dividing range of hills runs N.N.E. along the central axis of the Protectorate, and reaches an altitude of 3,280 ft. above sea level. This hill range extends south-west into the Gold Coast territory, and north-east into Dahomey. The rocks of the dividing range include quartzites, mica-schists, itabirites, phyllites, and some altered igneous rocks. Their strike is approximately north-east. They are known as the Togo series. Their age is doubtful, but they are probably pre-Cambrian.

To the east of this dividing range and forming a broad longitudinal strip in the eastern portion of the Protectorate

occur pre-Cambrian gneisses with intrusions of granite and gabbro.

On the western flank of the dividing range are younger beds, including conglomerates, quartzites, slates, and iron ores. These are known as the Buëm beds; their age is doubtful, but they are possibly Lower Palæozoic, or even older.

The western strip, occupying the valley of the Oti and the area to the west, consists of the Oti series, including conglomerates and other detritus derived from the Buëm beds. They are younger than the Buëm beds, but their exact age is doubtful. The Oti beds are horizontal, or but slightly inclined, and they are not traversed by intrusions.

The coastal district has a cover of recent alluvium; but under this there are beds that are probably of Tertiary age, including limestone of good quality.

The economic mineral occurrences of note in Togoland are those of iron ore, gold, chromite, bauxite, and limestone. Of these the iron ores have been worked by the natives, but otherwise no mining of note has been done. Indeed Togoland has no mineral industries comparable with those of German East and German South-West Africa.

Iron Ore.—Iron ores of the hæmatite variety occur abundantly at many localities, but chiefly as itabirites in the Togo series and as lenticular masses in the Buëm series. In the Sokode-Bassari district, some 235 miles from the coast, there are large iron-ore deposits forming the hill of Banyeli in the Buëm series, associated with conglomerates and sandstones. The ore mineral is massive hæmatite. A sample gave the following results on analysis:

		Per cent.
Ferric oxide	Fe_2O_3	89·51
Silica	SiO_2	9·47
Alumina	Al_2O_3	0·24
Manganese oxide	Mn_3O_4	0·16
Phosphoric oxide	P_2O_5	0·03
Sulphuric anhydride	SO_3	trace
Loss on ignition		0·30
Lime and magnesia		absent

The analysis shows that this ore is one of good quality. It is roughly estimated that there is not less than 20,000,000

tons of ore available, containing at least 50 per cent. of metallic iron. At present, however, this deposit is far removed from transport facilities. The railway from Lome does not run beyond Atakpame, which is about 109 miles from the coast. Exportation of the ore to Europe is, therefore, out of the question; but it may be possible to smelt the ore economically in the Protectorate, using water power to generate the electrical energy required. A limestone of good quality for use in smelting occurs at Tokpli (see below).

Gold.—Gold occurs in very small amounts in the eastern part of the Protectorate in quartz veins traversing the gneisses, and in the recent alluvium resulting from the disintegration of these veins. Gold occurs in the alluvial deposits of the head waters of the river Monu. Auriferous quartz-veins with galena, pyrite, and chalcopyrite occur in the Atakpame and Sokode districts. In all cases hitherto investigated, however, the amount is very small and gives no promise from a gold-mining standpoint.

Gold has also been found in conglomerates of the Buëm series at Kpandu. These conglomerates resemble the Gold Coast banket, but the samples examined did not carry more than one pennyweight per ton, and usually the amount was much smaller than this.

Chromite.—Masses of chromite containing a little nickel are stated to occur in serpentine at a locality to the S.S.W. of Atakpame.

Bauxite.—Bauxite resulting from the lateritisation of gabbro is reported to occur in the area south-east of Misahöhe.

Limestone.—Fossiliferous limestone of good quality and possibly of Eocene age is found at Tokpli on the river Monu, at the eastern boundary of the Protectorate and about 30 miles from the coast. This limestone gave the following results on analysis:

		Per cent.
Calcium carbonate	$CaCO_3$	95·59
Magnesium carbonate	$MgCO_3$	0·76
Silica	SiO_2	1·50
Ferric oxide	Fe_2O_3	1·16
Alumina	Al_2O_3	0·44

This analysis shows that the limestone is one of good quality and suitable for the manufacture of mortar and Portland cement.

Lead Ore.—In the Atakpame district, a mile or so to the east of Agbandi, there are quartz veins containing pockets of galena. The galena is slightly argentiferous; it is associated with pyrite and chalcopyrite; at the surface the galena is altered to cerussite and pyromorphite.

Exports

The first of the following tables shows the quantity and value of the chief exports from Togoland in 1911 and 1912, together with the chief countries of destination in 1912. Detailed figures for 1913 are not available, but the exports of the most important products in that year are shown in the second table.

Product.	1911.		1912.		Chief countries of destination in 1912.
	tons.	£	tons.	£	
Maize	2,644	8,712	1,343	11,555	Neighbouring countries in Africa.
Yams	898	3,144	322	3,603	Neighbouring countries in Africa.
Cassava and cassava meal	1,074	4,452	578	7,409	Neighbouring countries in Africa.
Cocoa	227	8,700	278	12,151	All to Germany.
Kola nuts	3	116	12	767	Neighbouring countries in Africa.
Peppers	46	453	45	1,064	Neighbouring countries in Africa.
Copra	187	3,193	161	3,064	Germany and France.
Palm kernels	13,073	178,932	11,452	168,978	Germany.
Palm oil	3,949	84,410	3,284	70,643	France and Germany.
Ground nuts	129	1,176	82	1,309	Neighbouring countries in Africa.
Shea nuts	34	1,192	39	1,263	Neighbouring countries in Africa.
Cotton seed	648	1,701	574	1,323	United Kingdom and Germany.
Raw cotton	509	27,706	542	25,745	Germany.
Piassava and Sisal	10	14	17	357	All to Germany.
Kapok	5	311	7	357	All to Germany.
Wood of all kinds	170	350	137	126	Neighbouring countries in Africa.
Rubber	143	41,615	163	48,787	Germany.
Live animals	—	20,987	—	30,737	Neighbouring countries in Africa.
Ivory	2	1,797	2	2,085	Germany.
Hides and skins	8	607	10	609	Germany & neighbouring countries in Africa.
Total exports	—	465,878	—	497,945	—
Total trade (imports and exports)	—	946,879	—	1,069,336	—

Exports in 1913

Product.	Quantity.	Value.
	tons.	£
Maize	3,526	14,409
Cocoa	330	16,660
Copra	129	3,015
Palm kernels	7,025	127,905
Palm oil	1,115	25,900
Cotton seed	563	1,372
Raw cotton	495	29,101
Kapok	9	472
Rubber	89	18,029
Live animals	—	21,505
Ivory	3	2,806
Total exports	—	456,815
Total trade (imports and exports)	—	988,439

BRITISH COLUMBIA TIMBERS

The forests of British Columbia have long been recognised as among the most valuable of the natural assets of the Province, and their exploitation has called forth abundant enterprise, supported by very considerable capital, on the part of those who have realised the possibilities of the extensive and diversified character of the forest resources of the country. The report issued by the Dominion Forest Branch for 1913 shows that the lumber production of British Columbia for the year mentioned surpassed that of all other Provinces, the cut being 1,173,647 m. ft. B.M., followed by Ontario with 1,101,066 m. ft. B.M. In the same year forest products, with an estimated value of $33,650,000, ranked first among the leading industries of British Columbia, but for some time past it has been recognised by the Government and the trade that, in face of the restricted local market, and the powerful competition of the United States, Eastern Canada, and certain European timber-producing countries, the most urgent necessity of the lumber trade is the securing of wider markets for the export trade. It is stated that whereas in 1912 and 1913 the local market used one-fifth of the lumber production in the Province, the proportion fell to one-twentieth in 1914; further, the keenest competition may be expected from American and Eastern Canadian mills in supplying

the Canadian prairie, which is the only important market developed for British Columbia timber during the past decade. It is urged that in furthering the interests of the lumber industry State assistance can be most effectively employed in three directions, viz. (1) by obtaining reliable data as to the strength and other technical characteristics of the leading species of timber; (2) by studying external markets and supplying the information obtained to the trade; (3) by bringing the produce of British Columbia to the notice of the markets which it is desired to enter. Efforts have already been made in these directions, notably in the case of the last mentioned. Through the Forest Branch of the Department of Lands, carefully prepared exhibits of British Columbia timbers have been dispatched for exhibition at important centres of the principal lumber-importing countries of the world. The exhibit intended for London has been installed in the Canadian Section of the Public Exhibition Galleries of the Imperial Institute, where the samples may be inspected on weekdays from 10 a.m. to 5 p.m. In these circumstances it has been considered desirable to publish a description of the exhibit referred to, together with a statement regarding the technical properties of the timbers concerned.

The British Columbia forests of merchantable timber are in the main distributed along the coastal region (notably in Vancouver Island) and in the river valleys of the interior. The Province is divided into Forest Districts conveniently arranged in two groups, viz. (1) east of the Cascade Range, including the Kamloops, Nelson, Tête jaune Cache, Cranbrook, Fort George, Hazelton, Vernon, and Lillooet districts; and (2) west of the Cascades, including the districts of Vancouver, Vancouver Island, and Prince Rupert. Owing to the nature of the country it is not yet possible to give a precise statement of the actual area under forest, but the extent may be judged from the fact that as a result of the reconnaissances by the field parties of the Government Forest Branch during 1914 an additional stand of 30,000,000,000 ft. of timber was located.

The forests differ considerably in character from those occurring in other provinces of Canada. The trees are

much larger and of closer stand, 100 to 150 cords per acre being regarded as a fair average for good timber lands, while 500 cords per acre is not uncommon. Growth is also very rapid as a result of the prevailing atmospheric conditions, and the relatively mild winters are of further significance inasmuch as they render lumbering operations possible all the year round.

The coast is heavily timbered as far north as Alaska, the forest line following the indentations of the shore and the river valleys. The four chief merchantable species are Douglas fir, red cedar, western hemlock, and Tideland (Sitka) spruce. The Douglas fir is the most valuable and widely distributed species, and along the coast extends to Knight's Inlet at the north of Vancouver Island, where it is succeeded by the cypress (yellow cedar) in a region where the red cedar, western hemlock, and Tideland spruce are the principal timber trees. All the species named, with the exception of the cypress, also attain large proportions in the river valleys of the interior. The forests contain a large number of species of secondary value for commercial purposes, of which the more important are western white pine, black pine, bull pine, balsam pine, western larch, Engelmann spruce, western white oak, aspen, broad-leaved maple, canoe birch, and madrona.

The special exhibit referred to above is concerned only with the four leading species, viz. Douglas fir, western hemlock, red cedar, and Tideland (Sitka) spruce. The exhibit comprises the following items:

1. *A series of five doors*, of different patterns, arranged to swing on a vertical standard. All are manufactured from Douglas fir, but are "finished" in different styles, each door showing two different finishes. The ten finishes are: natural, light oak, weathered oak, English oak, light mahogany, dark mahogany, golden oak, early English, silver grey, green weathered.

2. *A series of finished panels* (6 ft. in length) of the following woods: Douglas fir, in natural, golden oak, and dark mahogany finishes; hemlock, natural finish; Tideland spruce, natural finish; and red cedar, natural finish. The panels are built into a frame of Douglas fir.

3. *Sixty-six hand specimens* arranged on a stand made from Douglas fir. The specimens include four typical samples of Douglas fir, red cedar, hemlock, and Tideland spruce respectively, and examples of mouldings, ceilings, pulley styles, channel and other rustics, casings, quarter-rounds, edge-grain floorings, shingles, drop and other sidings, three- and five-ply veneers, and creosoted samples, manufactured from these timbers. The stand also contains descriptive labels affording full information in regard to the technical properties of the timbers. Copies of these labels may be obtained on application.

The following series of photographs illustrating the British Columbia lumber industry is also shown: (*a*) Douglas fir trees, (*b*) Douglas fir structural timber, (*c*) ships loading British Columbia lumber, (*d*) loading Douglas fir creosoted paving blocks, (*e*) part of an order for 160,000 creosoted ties for India, (*f*) cutting British Columbia Douglas fir veneer, (*g*) drying British Columbia Douglas fir veneer, (*h*) a British Columbia mill, (*i*) general view of mill yard, (*j*) lumber ready for drying kiln, (*k*) a British Columbia pulp mill, (*l*) pulp and paper mills, (*m*) widest paper machine in America, in a British Columbia paper mill, (*n*) splitting British Columbia red cedar into quarter blocks.

Description of Timbers

1. *British Columbia Douglas Fir (Pseudotsuga taxifolia)*

This tree, which is also known as Oregon pine, yellow fir, and red fir, is the most abundant and valuable timber species in British Columbia. The largest specimens are found on Vancouver Island, and along the coast, and in river valleys of the mainland near the sea. The average height of trees felled for lumber is about 150 ft., but specimens up to 250 ft. high, and 10 ft. diameter, are available.

Qualities and Uses. (*a*) *As a structural timber.*—In virtue of its strength, durability, appearance, lightness (28 lb. per cubic foot, kiln-dried), and ease of handling and working, Douglas fir is pre-eminently a structural timber. Its durability and resistance to decay render the wood of

special value for railway cars and sleepers, piling, bridge and trestle timbers, ships, barges, docks, and warehouses.

(*b*) *As paving blocks.*—The wood is easily creosoted and possesses a natural hardness. Douglas fir paving blocks are found to be resilient, durable, silent, and almost impervious to water.

(*c*) *As flooring.*—The timber when sawn edge-grain makes an excellent flooring timber, taking a high polish and wearing long and evenly without splintering.

(*d*) *For sashes and doors.*—The timber has proved popular for these purposes on account of its general qualities, strength and ease of working.

(*e*) *For inside finish* (veneer) Douglas fir is regarded as possessing special qualities, notably beauty of grain, hard surface, resistance to warping, shrinking, or swelling, and ability to take stains and paints.

A statement regarding the physical constants of the timber will be found below.

2. *British Columbia Red Cedar* or *Giant Arborvitæ* (*Thuya plicata*)

This tree stands next in importance to Douglas fir. It attains its greatest size on Vancouver Island and along the coast, and is also abundant on the slopes of the Selkirk and Coast Ranges, but is rarely found in the dry interior. This species is the largest of the Canadian cedars, averaging from 100 to 150 ft. in height and 3 ft. in diameter; specimens 200 ft. by 15 ft. diameter are found.

Qualities and Uses.—The outstanding qualities of red cedar are its practical immunity from the action of the weather, and its lightness (23 lb. per cubic foot, kiln-dried). The wood is soft, with a close, straight grain, and takes stains and paints well. Hitherto the main application of red cedar has been in the manufacture of roofing shingles, but its durability renders it especially suitable for the following purposes:

(*a*) *Posts, telephone and other poles*, on account of suitable taper and long lengths; decay at the ground line is resisted.

(*b*) *Inside finish*, in virtue of a distinctive grain, a smooth, high finish, and easy painting and staining.

(*c*) *Boats and canoes.*—High resistance to weather action, and the long, wide, clear lumber obtainable make the timber very suitable for this class of work.

(*d*) *Linings of wardrobes, cupboards, and store-rooms.*—The pleasant odour of red cedar is stated to be obnoxious to moths and other insects.

3. *British Columbia Hemlock, Western Hemlock* (*Tsuga heterophylla*)

This tree is abundant along the coast and in the Selkirk mountains. The average dimensions are from 130 ft. to 160 ft. in height, and from 2 ft. to 3 ft. in diameter, with corresponding maximum sizes of 200 ft. and 5 ft. respectively.

Qualities and Uses.—The strength of this timber is stated to be only 12 per cent. less than that of Douglas fir, and its weight is 32 lb. per cubic foot, kiln-dried. (Other determinations give 27 lb. per cubic foot.) The wood is especially suitable where ease of working, appearance, strength, lightness, and absence of "taste" are necessary qualities; when exposed to weather the wood should be treated with paint or other preservative. Specific uses suggested are as follows: framing and shelving; flooring (cut edge-grain and used in dry situations); bridge and trestle timbers; lath, inside finishing; boxes, barrels, grain-bins, and stables, the wood being strong, light, and distasteful to rodents. The timber has also been used successfully for piling in the Pacific North-West.

A statement of physical constants will be found below.

4. *British Columbia Spruce, Tideland Spruce* (*Picea Sitchensis*)

This spruce is found chiefly in the neighbourhood of the coast, being relatively more abundant in the north. The timber is used locally for a great variety of purposes, but it is probable that its chief application in the future will be as a pulp-wood. Average sizes are 150 ft. high and 4–5 ft. in diameter, with a maximum of 200 ft. high and 10 ft. diameter. Weight (kiln-dried), 26 lb. per cubic foot.

Qualities and Uses.—The timber is white, odourless, and without taste, being free from resin. It does not split when nailed. Special applications suggested are as follows:—

(*a*) *Framing, sheathing, shelving, and sub-flooring.*—The timber is well suited for these purposes, but is not sufficiently strong for heavy structural work.

(*b*) *Boxes*, in view of the satisfactory nailing qualities and lightness. The absence of taste is an additional advantage in this connection, and for the same reason the wood is largely used for refrigerators and linings of refrigerator cars.

(*c*) *Finish.*—The wood is obtainable in good sizes, and takes stains and paints well.

(*d*) *Sashes and doors.*—Well suited for this purpose, and also for pumps and windmills, in the construction of which it is supplanting poplar.

(*e*) *Oars and paddles.*—British Columbia spruce is said to be unequalled for these articles, being light, not liable to warp, and obtainable in clear lengths.

Results of Mechanical Tests

(Values published by the British Columbia Government).

No. of tests: Douglas fir, 182; Western hemlock, 39; Norway pine, 49.
Timbers graded by rules proposed by the Forest Products Laboratory of the U.S.A. Federal Government.

Species.	Weight per cubic foot (oven dry).	Modulus of rupture, per square inch.		
		Grade I.	Grade II.	Culls.
	lb.	*lb.*	*lb.*	*lb.*
Douglas fir	28	6,919	5,564	4,174
Western hemlock	27	5,615	4,658	—
Norway pine	25	4,821	3,764	3,255

Species.	Weight per cubic foot (oven dry).	Fibre stress at elastic limit per square inch.			Modulus of elasticity: 1000 lb. per square inch.		
		Grade I.	Grade II.	Culls.	Grade I.	Grade II.	Culls.
	lb.	*lb.*	*lb.*	*lb.*			
Douglas fir	28	4,402	3,831	2,914	1,643	1,468	1,206
Western hemlock	27[1]	3,689	3,172	—	1,481	1,360	—
Norway pine	25	3,082	2,364	2,144	1,373	1,204	962

[1] *Other determinations give 32 lb. per cubic foot.*

Bending Tests on Douglas Fir

Air-dried material and green material with defects, graded according to Pacific Coast Export Grading Rules. Size, 5 in. by 8 in. by 15 feet. Average values.

Grade.	Fibre stress at elastic limit per sq. in.	Modulus of rupture, per sq. in.	Modulus of elasticity: 1,000 lb. per sq. in.
	lb.	*lb.*	
Select:			
Air-dried material	5,814	7,801	1,256
Green material	4,320	6,147	1,698
Merchantable:			
Air-dried material	5,389	7,359	1,991
Green material	3,532	4,946	1,513
Seconds:			
Air-dried material	3,981	5,170	1,613
Green material	3,344	4,618	1,419

Compression and Shear Tests on Air-seasoned Wood

(Values published in *Circular* 189, *Forest Service*, *U.S. Dept. Agric.* 1912).

Species.	Compression parallel to grain.					
	Size.	No. of tests.	Moisture per cent.	Crushing strength at E.L. per sq. in.	Modulus of elasticity, 1000 lb. per sq. in.	Crushing strength at maximum load, lb. per sq. in.
	in.			*lb.*		
Douglas fir	2 × 2	247	18·7	3,842	1,084	5,002
Western hemlock	2 × 2	463	17·0	4,560	1,923	5,403
Norway pine	2 × 2	44	11·2	—	—	7,550
Douglas fir	6 × 6	259	20·3	3,271	1,038	4,258
Western hemlock	6 × 6	102	18·6	4,840	2,140	5,814
Norway pine	6 × 7	4	15·2	2,670	1,182	4,212

Species.	Compression perpendicular to grain.					Shear.		
	Stress area.	Height.	No. of tests.	Moisture per cent.	Crushing strength at E.L. per sq. in.	No. of tests.	Moisture per cent.	Shear strength per sq. in.
	in.	*in.*			*lb.*			*lb.*
Douglas fir	4 × 4	6	49	24·0	613	—	—	—
Western hemlock	4 × 4	4	6	15·9	488	—	—	—
Norway pine	—	—	—	—	—	—	—	—
Douglas fir	4 × 8	16	44	20·8	732	465	22·1	822
Western hemlock	7 × 6	15	25	18·2	514	131	17·7	924
Norway pine	2 × 2	2	36	10·0	924	44	11·9	1,145

SISAL HEMP: ITS CULTIVATION, PREPARATION, AND UTILISATION

DURING the last thirty or forty years, European hemp, the fibre derived from the stems of *Cannabis sativa*, which for many centuries has been employed for the manufacture of rope and twine, has met with a gradually increasing competition from certain other fibres, such as Manila hemp, Sisal hemp, Mauritius hemp, and New Zealand hemp. These fibres differ considerably from true hemp in being of a harder texture owing to the lignification of the fibre substance. In the following pages an account is given of Sisal hemp with particular reference to its industrial significance.

Sisal hemp, so-called from the name of a port in Yucatan, Mexico, whence it was first exported, is a valuable cordage fibre derived from the leaves of *Agave sisalana* and certain other species of agave. These plants are members of the Natural Order Amaryllidaceæ; they are commonly, but erroneously, spoken of as "aloes," and must not be confounded with the true aloe, which is of widely different character. The Sisal plant has a short trunk bearing a number of thick, fleshy leaves, which range from 3 to 6 ft. in length and from about 4 to 6 in. in width. At a certain age, which varies in different countries and seems to depend largely on the climatic conditions, it throws up a "pole" or flowering stem, 20 to 30 ft. high. The flowers are produced in dense clusters at the ends of short lateral branches, and after they have begun to wither, buds arise in the axils of the flower-stalks. From these buds arise small plants, known as "bulbils," which grow to the length of a few inches and then fall to the ground and, under suitable conditions, take root. After the production of the bulbils, the whole plant withers and dies.

The agaves are indigenous to South America and the southern parts of North America, especially Mexico. They have been introduced into many other countries, including Florida, the Bahamas, and other parts of the West Indies, British Honduras, South Africa, East Africa, West Africa,

Madagascar, Mauritius, India, Indo-China, the Dutch East Indies, the Philippine Islands, the tropical parts of Australia, Papua, Fiji, and Hawaii.

There are a great many different kinds of agaves in existence, and so much confusion has arisen with regard to their nomenclature that it is often extremely difficult to establish the identity of plants yielding commercial varieties of fibre. Comparatively recently, however, Professor Lyster Dewey, of the United States Department of Agriculture, has stated that there are only three species which are concerned with the question of the commercial production of Sisal hemp. These are as follows: (1) *Agave fourcroydes*, Lem., the Yucatan Sisal plant, which furnishes over 90 per cent. of the world's supply; the leaves of this species bear marginal spines. It was formerly known as *A. rigida* var. *elongata*, Baker, and occurs in Mexico, Cuba, and South America, and has been introduced into East Africa. (2) *Agave sisalana*, Perrine. This species is grown for local use by the natives of Central America and Southern Mexico, but is not exported from Yucatan to any great extent. It is cultivated commercially in the Bahamas, West Indies, East Africa, India, Indo-China, and to a small extent in Java. (3) *Agave Cantala*, Roxb. This is the maguey plant of the Philippine Islands and is grown in limited quantities in Java and India.

Production

The first attempts to introduce Sisal hemp into commerce were made in Mexico in 1839. The fibre was cleaned in a primitive manner and was afterwards packed in loose bales and sent to New York, where it found a market but was not very remunerative. The methods of preparation were so slow and tedious that, even with the cheap labour of that time, the cost of production was discouraging. The State Government, recognising the need for a suitable machine to extract the fibre, offered a prize to the inventor of an apparatus capable of producing a certain quantity per hour. This offer resulted in the invention of the "raspador" machine (see page 439) by a Franciscan friar, and led to a gradual expansion of the industry. The following

figures illustrate the development since 1880. In that year the exports of "henequen" (as the product is termed in Mexico) amounted to about 18,820 tons; in 1885, 44,580 tons; in 1890, 46,680 tons; in 1895, 63,900 tons; in 1900, 83,270 tons; in 1905, 99,500 tons. Since 1905 the annual export has been, on the average, rather over 100,000 tons per annum. The value of the fibre exported from Mexico in the year 1913 amounted to £3,058,474 (calculated on the basis of the Mexican peso having a value of 1*s.* 6*d.*). A large proportion of the fibre (over 90 per cent.) is exported to the United States, where it is employed for the manufacture of binder twine used in harvesting the immense crops of the Western States. The rest of the exports are consigned to European countries.

Imports of Sisal Hemp into the United States

From	1909.	1910.	1911.	1912.	1913.
	tons.	*tons.*	*tons.*	*tons.*	*tons.*
Mexico	87,360	94,838	111,405	103,683	136,559
Germany [1]	612	1,559	2,285	6,731	13,295
United Kingdom	850	450	700	789	675
British West Indies [2]	2,531	2,869	2,987	3,195	3,023
Cuba	—	—	—	—	44
British India	20	112	49	16	—
Dutch East Indies	59	44	87	—	—
Philippine Islands	—	—	32	—	—
East Africa Protectorate	—	—	148	—	—
Other countries	19	94	34	53	273
Total quantity	91,451	99,966	117,727	114,467	153,869
Total value	£2,128,310	£2,383,442	£2,519,284	£2,472,259	£3,709,129

[1] *Probably mostly or entirely derived from German East Africa.*
[2] *Almost entirely from the Bahamas.*

The Sisal hemp, or "pita" plant, has long been acclimatised in the Bahamas, but was not seriously regarded as worthy of systematic cultivation until 1888, when the Governor of the Islands took steps to encourage the establishment of a local fibre industry. During the next few years, several large undertakings purchased extensive tracts of land and planted them with the Sisal agave. The rapid growth of the industry is shown by the following data of the quantities and value of the fibre exported in certain years:

Year.	Quantity. Tons.	Value. £	Year.	Quantity. Tons.	Value. £
1891	9	149	1903	1,439	38,805
1892	30	692	1906	1,726	40,140
1893	52	1,200	1909	2,610	48,805
1894	79	1,728	1911	2,979	44,855
1895	242	3,987	1912	3,600	66,427
1897	402	4,522	1913	3,236	69,950
1899	607	16,942			

The whole of the fibre exported from the Bahamas enters the United States.

The production of Sisal hemp in India has not assumed important dimensions, although it has frequently been made a subject of commercial enterprise. The cultivation of agaves has been carried on for several years on a plantation in Assam, but the results have not been such as to warrant any great extension of the industry. In the Coimbatore District, Madras, the fibre has been extracted on a commercial scale from plants growing beside the railway. Sisal plantations have been established by several European undertakings in Madras, but the crop is not attractive to the ryots. In the Central Provinces, *Agave Cantala* is grown to some extent as a hedge-plant, but comparatively little fibre is extracted. Agaves also occur in Burma, but are not systematically grown for fibre. The actual amounts of Sisal hemp exported from India are not known, as the official returns do not class this fibre separately, but include it with Sunn or Bombay hemp (*Crotalaria juncea*), under the general heading of "hemp."

In the Philippine Islands the production of Sisal hemp, or "maguey" fibre, constitutes a comparatively small but gradually increasing industry. The exports, which are consigned chiefly to the United Kingdom and the Continent of Europe, amounted to 875 tons in 1901, 1,878 tons in 1905, and 2,606 tons in 1910. In the three following years the quantity and value of the exports were as follows:

	1911.	1912.	1913.
Quantity, *tons*	4,484	7,038	6,958
Value, £	61,158	114,436	123,115

The Sisal hemp plant was introduced into German East Africa in 1893. In that year the German East Africa Company ordered 1,000 plants from Florida, but only sixty-two of them

survived the journey. These were carefully tended in a plantation at Kikogwe, and new plants were propagated from them, so that in 1898 the number had increased to 63,000. In 1899, machinery was introduced for extracting the fibre. By the beginning of 1900 there were as many as 150,000 plants established, of which 4,000 were more than three years old, and were ready for cutting. The first shipment of fibre was made in 1900, and consisted of 7½ tons of value £155. From this time forward the industry progressed at a remarkable rate, as is shown by the following table, which records the quantities and value of the exports of the fibre from German East Africa during the years 1905–13:

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Quantity (metric tons) .	1,397	1,854	2,830	3,897	5,284	7,228	11,213	17,079	20,835
Approximate value (£) .	53,000	68,000	108,000	143,000	116,000	150,000	226,000	367,000	535,000

In British East Africa, the cultivation was started in 1903, experiments being made first in the Nairobi district, and a little later in other districts. The plants have now reached maturity on many of the plantations, and the extraction of the fibre has been commenced. On a plantation of about 1,000 acres at Punda Milia, in the Fort Hall district, a factory has been erected, which is provided with machinery for extracting and baling the fibre. Excellent results have been obtained, and consignments placed on the market have been reported to be of high grade, and have realised maximum prices. Machinery has also been installed at Nyali, on the mainland, opposite the island of Mombasa, and at other places in the Protectorate.

The industry has gradually undergone considerable extension, and at the beginning of the year 1913 the total area under cultivation amounted to about 7,000 acres, distributed as follows: Punda Milia, 1,000 acres; Makuyu, 750 acres; Voi, 1,000 acres; Nyali, 1,000 acres; Powysland, 1,160 acres; Gazi, 1,000 acres; Maseno, 600 acres; other areas, about 490 acres. Several improvements have been made in the extracting machinery, and simplified methods of drying and brushing the fibre are being adopted, which

will effect an economy in labour. Sisal plants grown at the coast yield a higher percentage of fibre than those grown in the highlands, and also furnish a finer fibre, but in the highlands a larger yield per acre is obtained, and the cost of labour is less. The prospects of the industry appear very promising, both at the coast and in the highlands.

The exports of Sisal hemp from British East Africa in the year 1913-14 were as follows:

To—	Quantity. Cwts.	Value. £
United Kingdom	16,573	9,670
Germany	811	473
United States	4,083	2,382
Total	21,467	12,525

The cultivation of Sisal hemp has been undertaken recently in the Nyasaland Protectorate, and, in 1914, about 400 acres in the Blantyre district were devoted to this crop. The cultivation of experimental plots at various altitudes in Nyasaland has shown that the higher localities are too cold, and that the most satisfactory results are obtained below 2,500 ft.

Efforts are being made to establish a Sisal hemp industry in Papua, and in 1914 the area under cultivation amounted to 3,110 acres. During the year 1913-14, 142 tons were exported, of the value of £3,633.

Experiments in Sisal hemp growing were commenced in Fiji in 1907, and satisfactory results were obtained at the Nasinu and Lautoka Experiment Stations, situated respectively in the wet and dry regions of the Island of Vitilevu, but the dry zone was found to be best adapted to the crop. Efforts are being made to encourage planters to take up the cultivation.

Sisal hemp is also being grown in comparatively small quantities in Mauritius, Jamaica, and certain other islands of the West Indies, and in Queensland and the Northern Territory, Australia. Experiments have been made in Uganda, Rhodesia, and various other parts of the British Empire.

Specimens of Sisal hemp grown in most of the British

possessions referred to in the foregoing paragraphs have been examined at the Imperial Institute, and the results of their examination have been published in previous numbers of this BULLETIN. Among them may be mentioned samples from India (1906, **4**, 25; 1909, **7**, 11; 1912, **10**, 216), East Africa Protectorate, Uganda, and Nyasaland (1909, **7**, 160), Papua (1912, **10**, 214); Mauritius (1910, **8**, 9), Rhodesia (1904, **2**, 168), Sierra Leone (1907, **5**, 107), and the Federated Malay States (1914, **12**, 39).

CULTIVATION

Climate and Soil

The Sisal plant requires a tropical climate with moderate atmospheric humidity. It is very hardy, but is liable to be injured by excessive rain.

It is usually stated that the plant flourishes on rough, dry, stony or rocky soils which are unsuitable for other crops, but there is little doubt that good soils are not unfavourable. On poor soils, the plants are of somewhat inferior appearance, but yield leaves containing a large proportion of fibre, whilst on rich soils longer leaves are produced which furnish comparatively less fibre. It is probable, however, that in the latter case the greater length of the leaf more than compensates for the lower percentage of fibre. In general, it may be stated that the most suitable soil is a dry, permeable, sandy loam, containing a certain amount of lime. Good drainage is of great importance, as the roots of the plants are sensitive to moisture and are liable to be seriously injured by standing water.

Preparation of the Land

The land selected for a plantation should be fairly hilly in order to allow of easy drainage. Most writers agree that it is not necessary to break up the soil to any great extent; but the land must be cleared of trees and scrub, and stumps must be uprooted in order to render the surface even. On the other hand, it is stated that in German East Africa the best results are obtained on land which has been thoroughly cleaned and well hoed. In any case,

it is essential that the undergrowth should be removed, as if the Sisal plants are shaded the fibre becomes weak and inferior. The land subsequently requires to be lightly hoed four or five times a year in order to keep it free from weeds.

Planting

The Sisal plant comparatively rarely sets seed, and its propagation is therefore effected by means either of bulbils which are formed in the manner already described (p. 430), or of suckers which arise from the rhizome. The bulbils are usually grown in nursery beds until about 8 to 12 in. high, and are then planted out. Suckers can be planted immediately after their removal from the parent plant. Planting is generally carried out during the rainy season, all fibrous roots and lower leaves having been first removed to facilitate new growth. The plants should be set in rows about 8 ft. apart. The distance between consecutive plants in the row varies a good deal in practice, but probably 6 ft. is generally the most satisfactory, this arrangement admitting about 900 plants per acre.

Harvesting and Yield

The period which must elapse before harvesting can be begun varies in different countries; but, in general, after about from three to five years, healthy plants will yield leaves ready for cutting. The cutting is effected by means of a special form of blade or sickle with a curved end. Each leaf is cut off close to the trunk, care being taken not to injure the younger leaves on the plant. The number of leaves which can be cut per annum varies greatly. It is estimated that in Mexico each plant yields about twenty-five leaves a year, whilst in East Africa double that number are obtained. The average weight of the leaves in the latter country is about 2 lb., and the yield of dry fibre is approximately 3 per cent. Hence the yield of fibre per acre containing 900 mature plants should amount to about 2,700 lb., and a yield of at least a ton per acre may therefore be anticipated.

As the result of actual trials carried out at Punda Milia,

it was found that 912 leaves, weighing 2,263 lb., or an average of 2·48 lb. per leaf, yielded 52½ lb. (2·32 per cent.) of dry, brushed fibre, equivalent to about 1 lb. of fibre from 17 leaves. The plants from which these leaves were cut were spaced 8 ft. × 8 ft., this arrangement giving 681 plants per acre. Taking 160 as the average number of leaves produced per plant during its life, the total yield per acre, when calculated by means of the above figures, is 6,240 lb., or a little less than 3 tons. As the plant lives at Punda Milia about three years after the first leaves are ready for cutting, these observations are in agreement with the estimated yield of 1 ton per acre per annum given in the preceding paragraph.

Duration of Life of the Plant

As has been already stated, the duration of life is determined by the production of the pole or inflorescence. In Mexico the plants are said to live for fifteen, or sometimes even twenty-five, years before poling, whilst in more tropical countries they live a much shorter period, the average length of life in East Africa being only about six years. In general, the duration of the plant appears to be largely dependent on condition of soil and climate. It has been asserted that the life may be prolonged by cutting out the pole as soon as it appears above the leaves, the plant being thus rendered available for fibre for nearly a year longer than it would be otherwise; but experiments which have been conducted in German East Africa do not support this view. The early poling of Sisal plants in East Africa has been much discussed, and has been regarded by some planters as a great disadvantage. It appears, however, that the comparatively short life is due to the fact that there are two growing seasons in that country, and growth is checked twice a year, whereas in less tropical countries there is only one growing season per annum. Thus it is evident that the plant in East Africa lives through approximately the same number of growing seasons as it does in other countries, but only about half as many years. Moreover, the number of leaves produced per plant (on the average about 200) is roughly

the same in each case, and hence the comparatively brief duration of life is rather an advantage than otherwise, as the total crop of the plant is produced in a relatively shorter time.

Since the plants in a Sisal plantation do not all pole at the same time, the work can be carried on continuously by the intercalary method sometimes adopted in German East Africa. As the plant lives for only about six years, cutting can only be carried on for two or three years before it dies. New plants are therefore continually inserted between the old ones, so that when one plant dies another is ready for cutting, and the work of the plantation can proceed without interruption. Some planters, however, do not approve of this method, but prefer to let all the plants in a plantation pole and die, and then allow the land to lie fallow for a year or more before replanting.

Extraction and Preparation of the Fibre

The fibre is extracted from the leaves by a process of crushing and scraping or "scutching." The leaves should be treated as soon as possible after they have been cut, as otherwise the juices become dry and gummy, thus rendering extraction more difficult. They should be graded according to length before being scutched, and the fibre of the different lengths should be kept separate. The strands of fibre must be kept as parallel as possible and not be allowed to become tangled. It must be borne in mind that good white fibre of uniform length and carefully cleaned and baled commands a much higher price than mixed fibre, ill-cleaned and badly baled.

Modern machinery for Sisal hemp extraction is based on the principle of the old "raspador," which was the earliest form of machine employed in Mexico. This machine consists of a wheel, like a 4-ft. pulley, with a 6-in. face, and with pieces of brass running across the face at intervals of about 12 in. The wheel runs in a heavy wooden case and makes about 110 revolutions per minute. The leaf is inserted through a small hole in the case, and held firmly at one end by a strong clamp, whilst

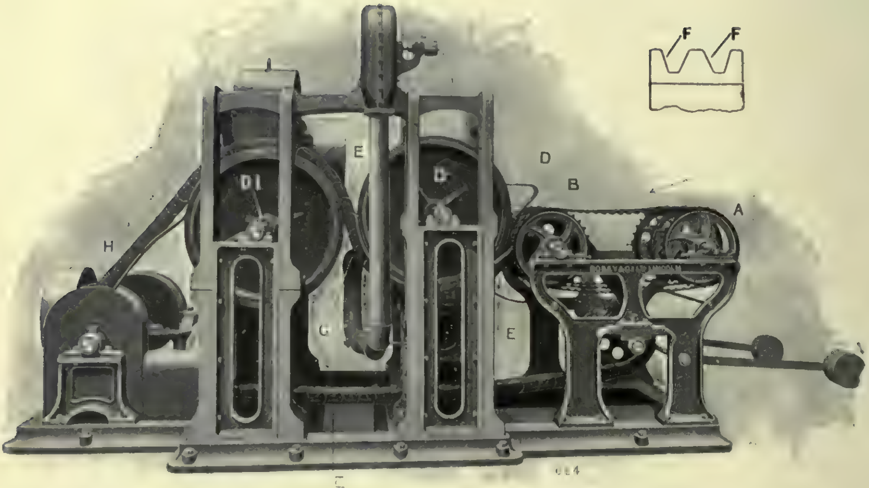
the rest of the leaf is allowed to whip downwards as the wheel rotates. A heavy concave wooden block, like the brake of a car-wheel, is brought by means of a lever on to the leaf and presses it against the revolving wheel. The leaf is thus crushed and the pulp and epidermal tissue are scraped away by the brass strips and thrown into a pit under the wheel. The fibre is then withdrawn and the leaf reversed, in order that the other end may be cleaned in the same manner.

The machines which are chiefly used in East Africa are the "New Corona," the "Mola," and the "Finigan-Zabriskie."

The "New Corona" machine, manufactured in Germany, is said to be capable of extracting about 2 tons of dry fibre per day, requires 30 h.p. to work it to its fullest capacity, and demands the services of four workmen. It consists essentially of two scutching drums armed with scrapers which work against concentric, brass-lined, cast-iron saddle pieces. The leaves are automatically pulled through between the drum and the saddle piece, one half of the leaf being extracted by each drum. The pulpy matter is thus scraped away from the fibre, leaving the latter in a condition in which, after washing and drying, it is ready for export.

The "Mola" machine, manufactured in Merida, Mexico, needs about 48 h.p. to drive it. It works more rapidly than the "New Corona," and can extract about 3 tons of fibre per day. The extreme velocity necessary to effect this, however, causes a comparatively large amount of waste, but this loss is usually regarded as compensated by the greater output. The bundles of leaves as brought in from the plantation are placed by one or two workmen on a travelling lattice which carries them up to a table in front of the machine. Four men are then required to open the bundles and lay the leaves on the conveyor, which introduces them to two raspadors, arranged at right angles to one another, where they are cleaned, one-half the leaf being stripped at a time. The fibre on leaving the machine slides down on a wooden frame and is then washed and dried.

PLATE I



The "Robey" Decorticator. Diagram illustrating method of working.

The "Finigan-Zabriskie," an American machine, is capable of extracting about 1 ton of fibre per day of 9 hours. It requires the services of three attendants, two to feed the leaves into the machine, and one to withdraw the fibre.

Several British firms are now manufacturing machinery for the extraction of Sisal hemp. Three machines are made by Messrs. Robey & Co., Ltd., Lincoln. These are (1) the "Duodecor," for the decortication of leaves not over 4 ft. long, which has two drums each 4 ft. in diameter, is capable of dealing with 10,000 leaves per hour, and requires a power of 50 i.h.p.; (2) the "Sixdecor," for decorticating leaves more than 4 ft. long, which has two drums, one of 4 ft. and the other of 5 ft. diameter, a capacity of 13,000 leaves per hour, and requires 60 i.h.p. to drive it; (3) the "Twendecor," for use with extremely long leaves, which resembles the "Sixdecor" in construction, requires 80 i.h.p., and can decorticate up to 20,000 leaves per hour. One of Messrs. Robey & Co.'s machines has been installed in the East Africa Protectorate on a plantation at the coast, north of Mombasa.

The construction of the machine may be best explained with the aid of the illustration (Plate I). The leaves are fed lengthwise on to the three link chains marked A, which work in the direction of the arrow. The leaf C, when reaching the point B, is drawn down and caught between the feed drum D and the conveyor chain E, which goes underneath the feed drum D; the section of the feed drum is shown in outline in the diagram, the conveyor chain working in the two grooves F F. The end of the leaf opposite to that which is held in the feed drum is drawn along, and the decorticating drum, which works at right-angles to the feed drum against a concave shoe, strips off the whole of the pulp and leaves only the clean fibre hanging down. When this clean fibre comes opposite the mouth of the blower G, it is blown forward, the other end still being held between the feed drum and the chain. The cleaned fibre is then caught between the conveyor chain E and the second feed drum D 1, the chain here passing over the top of the drum. The uncleaned portion

of the leaf passes between the second decorticating drum and its shoe, and is duly cleaned, the completely cleaned fibre being delivered at the point H.

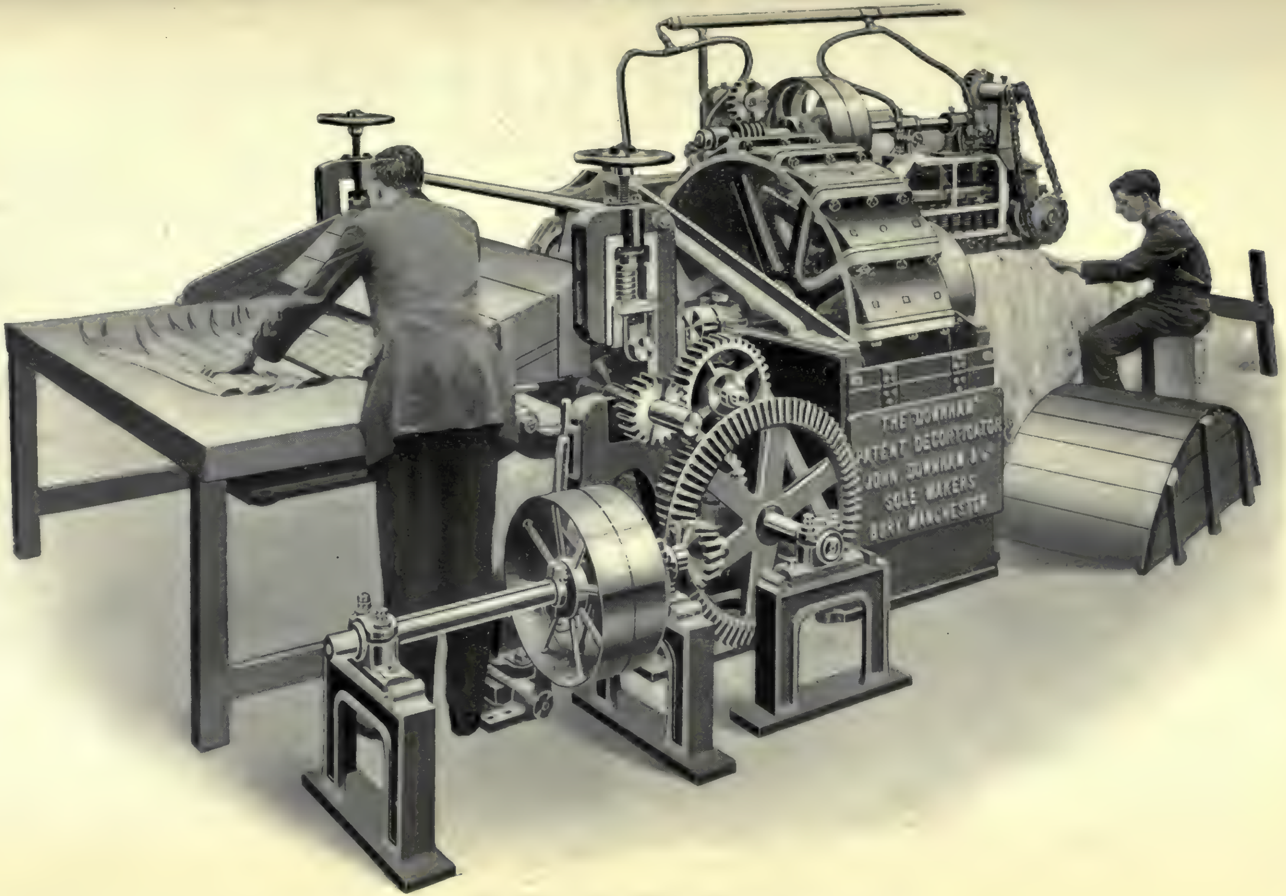
Another machine, constructed by Messrs. John Downham & Co., Bury, is capable of decorticating 120,000 leaves in 10 hours. The leaves are submitted to a preliminary crushing operation and then passed in succession over two decorticating drums. During the decorticating process the fibre is washed and freed from juice and extraneous matter by means of a jet of water under pressure. In the illustration (Plate II) the two decorticating drums are shown without their covers. The strippers or beaters on the periphery of the drums can also be seen as well as the upper and lower endless feed-chains by means of which the fibre travels automatically. The leaf-crushing apparatus and its upper crushing roller are on the left close to the man who feeds the leaves into the machine. The machine requires 38 b.h.p., including the power needed to drive the crushing apparatus.

The "Ajax" machine, manufactured at the Alma Machine Works, Liversedge, Yorkshire, is constructed on the double drum principle, has a capacity of 12,000–15,000 leaves per hour, and requires up to 50 h.p. to drive it. There is also a single-drum "Ajax" machine, capable of decorticating 2,500–3,000 leaves per hour, and requiring a driving power of 15 h.p.

A machine introduced by the World's Fibre Machinery Corporation, Ltd., and manufactured by Messrs. Greenwood & Batley, Leeds, differs from the foregoing machines in its mode of action. The leaf is treated by a combing and crushing process by means of rollers, and is then automatically passed on to a revolving drum on which are rows of sharp steel teeth; these teeth penetrate the leaf and remove the pulpy and epidermal tissues, leaving the fibre on the teeth, from which it is automatically lifted and removed.

Mention may also be made of a small machine manufactured by Mr. Ernest Lehmann, Manchester; it requires a driving power of about 2 h.p., and is capable of treating 10,000 leaves per day of 10 hours.

PLATE II.



The "Downham" Decorticator.

It is essential for the production of good, strong fibre that immediately after leaving the machine it should be well washed with clean water, as otherwise both strength and colour are impaired. The factory must therefore be provided with an ample supply of water. Drying is effected by hanging the fibre on lines in the open air, care being taken that it does not become wetted by rain. After drying, the appearance of the product can be greatly improved by the use of a brushing machine to ensure the removal of any particles of dried pulpy matter which may still adhere to it.

Cost of Production

The cultivation and extraction of Sisal hemp on a remunerative scale require a large amount of capital, as at least 500 acres must be planted to warrant the erection of a factory and the installation of the necessary machinery. The crop is therefore unsuitable for individual planters unless possessed of ample means, but it can be grown with considerable profit by a number of planters working in co-operation.

The cost of cultivating Sisal hemp and preparing it for the market varies greatly in different countries, and depends on the climate, soil, labour supply, and other local conditions. The following results, based on actual experience at Punda Milia in the East Africa Protectorate, are of interest in this connection. The establishment of a plantation of 1,000 acres requires a capital of £4,000. The cost of machinery required to prepare the fibre from the leaves produced on a plantation of this size is £5,000. A return cannot be expected until four years after the plantation has been established. As already stated, 1 ton of dry fibre per acre per annum may be anticipated for three years from the date of the first cutting. The cost of producing a ton of dry fibre is about £12, including £1 per ton for transport to the railway.

It is estimated that in German East Africa the net profit varies between 15 and 30 per cent., depending on the current price of the fibre. The crop possesses several advantages, among which may be mentioned that it is almost immune from the attack of insects, and practically

free from disease, and that the manufacture of the fibre can be carried on more or less continuously throughout the year.

Characters and Properties of Sisal Hemp

Sisal hemp consists of strands or filaments from 3 to 5 ft. long, of a nearly white or pale yellowish colour. It is very strong, but a little harder and less flexible than Manila hemp. The fibre from different sources varies a good deal in diameter. The strands are composed of a mass of ultimate fibres about 2–5 millimetres (0·08–0·2 in.) long, which are polygonal in transverse section, and have a large polygonal lumen. The fibre substance consists of a lignified form of cellulose. The commercial value of the product depends chiefly on its length, strength, colour, and freedom from pulpy matter of the leaves, which sometimes adheres to the fibre owing to inefficient cleaning.

Commercial Value

The market price of the fibre fluctuates in sympathy with that of Manila hemp. The average value of the best Mexican Sisal hemp on the London market during the years 1907–14 was about £25 per ton. The best fibre from East Africa usually realised £1 or more per ton in advance of that of the Mexican product. The extent to which the price is liable to fluctuation is illustrated by the following statistics. During 1908, Mexican Sisal was quoted at from £25 to £27 per ton. In 1909, the price fell gradually from £26 in January to £24 in April, and then rose rapidly to £29 10*s*., and remained at that figure from June to December. During 1910, the value gradually declined from £29 10*s*. in January to £20 in December. In the first half of 1911 the price was about £19–£20, but rose during the second half of the year to £22 10*s*. During the months of January to June 1912, quotations varied from £24 10*s*. to £25 10*s*., but during the latter half of the year the value rose to £37 10*s*. in November, and subsequently fell to £35 10*s*. per ton. The price remained at about this figure until September 1913, and then fell, until in December the fibre was quoted

at about £28 per ton. In 1914, prices declined somewhat during the first six months of the year, remained at about £26 10s. during July and August, and during the last four months fluctuated between £20 and £25 per ton. During the present year considerable embarrassment has been caused in the trade owing to the political situation in Mexico, and the increased freights, due partly to the European War, and prices have therefore been very erratic and uncertain.

Utilisation of Sisal Refuse

In the course of extracting the fibre from agave leaves a large quantity of refuse is produced. A good deal of consideration has been devoted to determining the best way of utilising this material. At the present time, the greater part of it appears to be used in the plantation itself for application to the soil. It has been stated, however, that it is better to dry and burn the refuse and employ the ashes as a manure, than to apply the fresh or dried refuse directly to the soil. Lommel (*Der Pflanzer*, 1911, 7, 531) has found that 100 lb. of the dry refuse yield about 13 lb. of ash, which contains about 80 per cent. of carbonate of lime, 11 per cent. of carbonate of potash, and 4 per cent. of phosphate of lime.

The refuse has also been suggested as a possible material for paper-making, and it has been stated that a company has been formed in Mexico for the utilisation not only of the leaf refuse but also of the stumps of the plants for the purpose. It is proposed to erect a mill in Yucatan, capable of working up 15 to 20 tons of the raw material per day. The work is to be restricted at first to the manufacture of half-stuff for export. Trials have been made at a mill in New Orleans which show that the material yields a very strong paper.

It has also been suggested that the leaf-refuse could be used as a source of alcohol, but it seems doubtful whether the employment of the material for this purpose would be remunerative, as considerable difficulty is found in fermenting it.

A patent has been taken out in Germany for the ex-

traction of oxalic acid and a wax, resembling Carnauba wax, from the refuse.

The utilisation of Sisal leaf waste in the fresh form as a feeding stuff for stock is reported to have given fairly satisfactory results. The waste contains a moderately high percentage of sugar, and it has been thought that it might also give good results when used in the dry form and in admixture with other food materials.

"Zapupe" Fibre

In conclusion, reference may be made to a fibre closely allied to Sisal hemp, and known as "Zapupe" fibre. The name "Zapupe" has been applied to several species of Mexican agaves, of which *A. Zapupe*, Trelease, and *A. Lespinassei*, Trelease, are the most important. The former is known as the "blue Zapupe," or "Estopier," whilst the latter is the "green Zapupe," or "Tepezintla." The fibre has lately been produced on a commercial scale in the neighbourhood of Tuxpam, and also in the northern parts of Vera Cruz. It is claimed that the plant bears leaves ready for cutting at a much earlier age than the Sisal agave, that it gives a larger yield of fibre per plant, and has a greater longevity. The fibre is of excellent quality and equal in value to Sisal hemp; the strands are usually somewhat finer than those of the latter fibre. A fuller account of the plant, together with the results of examination of specimens of the fibre at the Imperial Institute, will be found in this Bulletin (1913, **11**, 65).

THE FEEDING VALUE OF PALM KERNEL CAKE

In order to determine the value of palm kernel cake as a food for live stock in comparison with other foods, trials were arranged for at a number of agricultural colleges and elsewhere in Great Britain by Sir Owen Philipps, Chairman of the West African Section of the London Chamber of Commerce. The results of one of these trials, carried out at the Lancashire County Council Farm at Hutton, have already been referred to in this Bulletin (1915, **13**, 151).

The results of other experiments at present available are summarised below.

In a trial conducted at the North of Scotland College of Agriculture (*Bulletin* No. 20, 1915), the cake was compared with linseed and decorticated cotton seed cakes as a food for fattening cattle (bullocks and heifers). Three lots of animals were fed and otherwise treated alike, except that one lot received palm kernel cake, another linseed cake, and the third cotton seed cake in equal amounts. The basal ration consisted of turnips (cut swedes) and straw, except during a short time when, owing to a deficiency of straw, hay was fed once a day to all the stock. The experimental period was divided into three periods of twenty-eight days each. In the first period the bullocks received 5 lb. and the heifers 4lb. per head per day of a mixture of three parts of cake to two of locust bean meal, in the second period the bullocks received 8 lb. and the heifers 7 lb. of a mixture of five parts of cake to three of locust bean meal, and in the third period the bullocks received 9 lb. and the heifers 8 lb. of a mixture of five parts of cake, two of locust bean meal, and two of oats. At the close of the experiment there was very little difference, on the average, between the three lots of animals. They throve equally well, and made almost equal increases in weight, the small differences which were recorded being quite well covered by the experimental error. Palm kernel cake, however, gave considerably the best monetary return, the net cost of food per cwt. live weight increase being 43*s*. 4*d*., as compared with 45*s*. 6*d*. in the case of decorticated cotton seed cake, and 51*s*. 6*d*. in the case of linseed cake.

An experiment in the winter feeding of cattle was undertaken at the Edinburgh and East of Scotland College of Agriculture to test palm kernel cake, dried distillery grains, and a mixture of chaffed hay and Bombay cotton cake against Bombay cotton cake. Thirty-two two-year-old bullocks were fed over a period of four months on a basal ration of 100 lb. swedes, 3½ lb. medium wheat bran, and 7 lb. oat straw. One lot of eight animals received in addition an average of 4½ lb. Bombay cotton cake per head per day, another lot an average of 4⅛ lb. palm kernel cake, a third

lot 2 lb. Bombay cotton cake and 5½ lb. chaffed hay, and a fourth lot 4⅛ lb. dried distillery grains. The total live weight increase in the four lots was 1580, 1827, 1435, and 1811 lb. respectively; the outlay per cwt. of live weight increase, based on the average winter price for a few years previous to the war, and making allowance for the manurial values of the cakes, was 43*s.* 9*d.*, 39*s.* 5*d.*, 51*s.* 11*d.*, and 39*s.* respectively. The results indicated that palm kernel cake is a cheaper feeding stuff than first-class Bombay cotton cake and is practically equal in value to the best class of dried distillery grains. In the report on this trial it is pointed out that cattle do not eat the palm kernel cake "when it is first put before them, but in a few days they take it quite readily, and there appears to be no practical difficulty in feeding it to fattening bullocks when they are accustomed to it from the beginning of the fattening period." The butchers' reports indicated that palm kernel cake had no unfavourable effect on the quality of the beef, which, as a matter of fact, was reported to be very satisfactory.

At the Norfolk Agricultural Station, ten bullocks were fed on a ration consisting of 90 lb. swedes, 7 lb. hay and straw chaff, 3 lb. cotton cake (rising to 3½ lb.), and 3 lb. of linseed cake (rising to 3½ lb.). Another lot of ten bullocks, of approximately equal total weight to the first lot, were fed on the same ration except that the linseed cake was replaced by an equal weight of palm kernel cake. At the end of eight weeks the animals receiving linseed cake showed a total gain in weight of 1,240 lb., while those receiving palm kernel cake had gained 1,230 lb. As the difference between the two lots was considerably smaller than the probable error of the experiment, the results indicate that the two cakes have approximately the same feeding values. This is a highly favourable result for palm kernel cake in view of its low price as compared with that of linseed cake.

At the Agricultural College, Uckfield, Sussex, also, favourable results were obtained. It was found that palm kernel cake was equal to Bombay cotton cake as a milk producer and more valuable for beef production.

In an experiment carried out by Dr. Charles Douglas, Chairman of the Highland and Agricultural Society of

Scotland, some young cattle, which were wintering out with hay feeding, were given 2 lb. of palm kernel cake per day. These cattle wintered very much better than others which had hay only, and Dr. Douglas states that the superiority in their condition was such as to show that palm kernel cake is a very valuable food for field cattle, and as a result of his experience he strongly recommends it for this purpose. He adds that these cattle ate the cake greedily, but he was not successful in getting dairy cows to take to it.

At the Harper Adams Agricultural College, Shropshire, the cake was compared with decorticated cotton seed meal as a food for milch cows. Two cows were given 3 lb. of palm kernel cake, 4 lb. of dairy meal, and 2 lb. of linseed cake per head per day, and another two were fed on a similar ration in which the palm kernel cake was replaced by 2 lb. of decorticated cotton seed meal. After three weeks the cows were changed over, and at the end of six weeks the total yield of milk obtained from animals fed with palm kernel cake amounted to 3,412 lb., and from those fed with cotton seed meal to 3,471 lb. After the first day or two the cows took the palm kernel cake readily. It had no appreciable effect on the colour, taste, or smell of the milk, the butter produced was of quite satisfactory texture, there was a slight tendency to paleness, but it was of good flavour.

At the Armstrong College, Newcastle-on-Tyne, palm kernel cake was compared with Bombay cotton cake as a food for milch cows. The basal ration consisted of 56 lb. swedes, 12 lb. meadow hay, 6 lb. oat straw, 2 lb. malt coombs, 3 lb. soy bean cake, and ½ lb. oat straw chaff, to which was added 6 lb. of either palm kernel cake or cotton cake. Although the animals receiving palm kernel cake did not increase in weight in any undue proportion compared with those receiving the cotton cake, yet in a short time the former had looser skins with a glossier look, and a better "bloom." An important result of this trial was to show substantial evidence that palm kernel cake gives a higher percentage of fat in the milk. There was no evidence to show, however, that the total weight of butter

fat produced per day in the milk had been increased. The conclusion is reached that palm kernel cake is a very valuable addition to dairy cattle foods.

A similar trial was conducted at the Garforth Experiment Station, Leeds University, where palm kernel cake was compared with Egyptian cotton cake as a food for milch cows. Up to 4 lb. of cake per head per day were fed in each case. In this experiment also there was an increase in the yield of fat when palm kernel cake was fed, but it was only slight. The results also indicated a gain in the milk yield in favour of palm kernel cake of about 5½ lb. per day on a total yield for four cows of about 140 lb. per day.

At the Hampshire Farm Institute, Sparsholt, eighteen dairy cows, which had been receiving a mixture of soy bean and decorticated cotton cakes, were given palm kernel cake, in gradually increasing amounts from 1 lb. to 4 lb. per day. The milk and butter were quite normal. The results showed that while palm kernel cake is a safe and suitable food for dairy cows, it should be given from the commencement of the winter feeding, before the cows have become accustomed to other concentrated foods.

No systematic experiments with palm kernel cake have so far been carried out at the University College of North Wales, Bangor, but a good deal of the cake has been fed to dairy cows and fattening sheep, and Prof. R. G. White states that from careful observation of the animals he has no hesitation in recommending the use of the food, if it can be obtained at a reasonable price compared with other cakes, such as cotton cake. It was found that although the cows and sheep would not take to the cake at first, with the exception of a few animals they soon became accustomed to it and took it if mixed with a small quantity of other food.

A feeding trial comparing palm kernel cake with linseed cake as a feeding stuff for sheep has been conducted at the South-Eastern Agricultural College, Wye. Two lots of sheep were fed alternately on rations containing either linseed cake or palm kernel cake. The results were inconclusive as excessively wet weather prevailed during the

period of the experiment. No difficulty was experienced in getting the sheep to eat the palm kernel cake. They took to it immediately and seemed to relish it, and no bad effects whatever were observed from its use. The average increase in live weight per sheep per day was greatest during the time when the linseed cake was fed, but Mr. W. A. Stewart, in reporting the results of this experiment, states that he considers palm kernel cake is a better feeding stuff than the figures obtained show, and that a further trial is necessary before its value can be finally decided.

On the whole the results of these feeding trials are quite satisfactory, and British farmers need have no hesitation in employing palm kernel cake as a feeding stuff. Further testimony to the value of the cake is afforded by Dr. J. A. Voelcker, Consulting Chemist to the Royal Agricultural Society of England, in his Annual Report for 1914 (*Journ. Roy. Agric. Soc.* 1914, **75**, 271). He states therein that there is every reason why palm kernel cake should be extensively and advantageously used in this country, inasmuch as it is an excellent food, more especially for dairy stock. He mentions that one inconvenience attaching to the cake is that it does not keep as well as do linseed and cotton cakes, and that there is a tendency for it to turn rancid. It should be pointed out, however, that in the experiments conducted at the Lancashire County Council Farm at Hutton (this BULLETIN, 1915, **13**, 151) and at the North of Scotland College of Agriculture (p. 447), no difficulty was experienced regarding the keeping qualities of the cake. In the latter case it is stated that cake (containing 7·55 per cent. of oil) procured in the autumn of 1914 was still in a perfectly fresh and sweet condition in July 1915.

Enquiries instituted by the Board of Agriculture have shown that the cake is already being used to a certain extent by farmers in this country, and although opinions as to its merits vary somewhat, on the whole they are quite favourable. A fair amount is being used in Northumberland, Wales, and elsewhere; while it is expected that it will be extensively purchased in Staffordshire during the coming winter. In Hereford it is stated to be finding favour for

pig-feeding, the flesh of pigs fed on the cake being very firm.

Experience at the Imperial Institute confirms the opinion expressed by the Board of Agriculture that great interest is now being shown by British farmers in the use of palm kernel cake as a feeding stuff, over 200 enquiries on this subject having been received from farmers and others by the Technical Information Bureau of the Institute during July last.

As is usually the case with new feeding stuffs, some difficulty may be encountered in getting certain animals to take to palm kernel cake at first. In most of the trials referred to above the animals, both cows and sheep, took to it readily, and where any difficulty is encountered it is probably due to some idiosyncrasy in the animal. This could no doubt be got over by introducing the cake gradually, and mixed with other rations, or by adding a moderate quantity of flavouring material. In the case of sheep it may be advisable to damp the cake overnight, but in the case of dairy cows it has been recommended to feed it in a dry condition.

PRODUCTION AND UTILISATION OF RAPE SEED

The names rape and colza are those most commonly applied to the seeds and oils derived from a number of varieties of *Brassica campestris*, Linn. (Nat. Ord. Cruciferæ). Attempts have been made to classify these varieties into definite groups under distinctive names, but the task is extremely difficult, as the seeds of practically all varieties are sold, at any rate in this country, indiscriminately as rape seed.

The plant is believed to be a native of northern Europe. It belongs to the same natural order as the cabbage, turnip, etc., and resembles these in having large succulent leaves of bluish-green tinge, often covered with a whitish bloom. The height of the plant varies from 18 in. to about 4 ft., according to the variety and environment. The flowers are usually yellow. The seeds, which are borne

in black pods about 2 in. in length, are round, and vary in colour from creamy-white to dark brownish-red. They are in all cases very small, those of some varieties weighing only 0·07 grams per hundred seeds, whilst the largest weigh 0·68 grams per hundred seeds. In addition to the numerous varieties of *B. campestris*, annual and biennial forms also exist.

Cultivation of Rape as a Fodder Crop

When cultivated for fodder rape requires a moist, rich, loamy soil, and does not thrive as a rule on light, sandy soils or stiff clays; such soils as produce good crops of turnips, cabbages, wheat, or maize are well suited for fodder rape. In England rape is sown as early as April for feeding in August, or, if sown in August, it forms a useful feed during late autumn and early winter. Three to five pounds of seed per acre are sown on ground which has received a deep ploughing and thorough cultivation, such as is usually needed for small seed. The sowing is generally done by seed drills, 24 to 28 in. being allowed between the rows. The young plants have strong fibrous roots which soon obtain a good hold of the soil, and allow of harrowing without danger of damage. The kinds of rape most frequently grown as fodder in this country are the "Essex Dwarf" and the "Giant," the latter giving very large yields in the Fen districts. If sown too frequently on the same soil rape is liable to suffer from "finger and toe" disease, but this does not usually occur on chalky soils. Rape is fed to stock of all kinds, but by far the greatest quantity is fed to lambs and sheep. The area under rape in England in 1914 was 64,773 acres.

Cultivation of Rape for Oil-seed

In spite of the fact that enormous quantities of rape seed are produced in India and in certain European countries, comparatively little reliable information appears to exist relating to its cultivation for seed.

In India numerous varieties and races are grown as cold-weather crops in the plains and as spring crops

in the lower Himalaya, generally as a mixed crop with mustard, wheat, barley, or other crops. Planting generally takes place in September or October, the crop being harvested in February.

In northern France the crop is often grown after wheat. The seed is sown in July, preferably during wet weather, on a specially prepared seed bed, which has been well manured and is of fine tilth. The young plants are planted out after removal of the wheat crop, being placed about 18 in. apart in rows 2 ft. apart. Wider planting gives a better crop and more evenly ripened seed on very rich soil. A cheaper method is to sow direct in the field and thin out later in the season. In the spring, after frosts are over, the soil is well cultivated by horse hoe, and manuring then is beneficial. Harvesting takes place in July (*i.e.* twelve months after sowing), when the straw and seed pods turn yellow, care being taken not to allow the pods to ripen too far, as they readily shed their seed if over-ripe. After cutting, the plants are laid across the ridges to dry and ripen for a few days, and are then threshed; this can be effected by hand by using flails, the plants being spread on a large sail or other cloth to catch the seed. When dry the seeds are stored, but they must be turned frequently to prevent heating.

The yield of seed is very variable. According to Watt (*Commercial Products of India*, p. 177) the yield in India is 5 cwts. per acre. An average yield in France is stated (Spon, *Encyclopædia of Manufactures and Raw Materials*, 1882, p. 1384) to be about 9 cwts. per acre.

Properties and Uses of Rape Oil

The amount of oil in rape seed varies somewhat widely according to the variety of plant and the locality in which it is grown, the extreme variation being from about 33 to 45 per cent. According to Lewkowitsch (*Technology of Oils, Fats, and Waxes*, 1914, ii. p. 255) seed from the north of France contains 43 to 45 per cent., Danubian seed 38 to 40 per cent., and Indian seed 42 to 45 per cent.

Rape oil is prepared in India by the simple processes usually employed by native peoples. In Europe larger

quantities of oil are manufactured by expression and also by extraction with solvents.

In spite of the large number of varieties of *Brassica* which are used as sources of oil, the characters and analytical data of the different oils have been shown not to differ to any great extent (cf. Grimme, quoted by Lewkowitsch, *loc. cit.* 244). The analytical constants of commercial rape oils, according to various investigators, are as follows (Lewkowitsch, *loc. cit.* p. 245):

Specific gravity at 15° C.	0·913 to 0·917
Saponification value[1]	167·7 to 178·7
Iodine value . . . . *per cent.*	93·5 to 104·8
Volatile acids, soluble[1]	0·0 to 0·79
Solidifying point of fatty acids	11·7 to 13·6° C.

[1] *For the meaning of these terms see p.* 340.

Rape oil is a semi-drying oil, and is characterised by a high viscosity and a saponification value lower than that of any of the common oils of commerce. Crude rape oil is a viscous, dark-brown liquid, and is generally purified by treating with about 1 per cent. of strong sulphuric acid, which precipitates impurities and colouring matter, leaving a refined oil of yellow colour with a characteristic odour and peculiar harsh taste. The low saponification value of rape oil is due to the predominant constituent, trierucin; glycerides of rapic and arachidic acids have also been identified in rape oil, and other acids are certainly present.

Rape oil was formerly used in Europe and elsewhere to a very large extent as a burning oil; but its use for this purpose has declined owing to the substitution of petroleum. The principal use of the oil at the present time is as a lubricant; its high viscosity, which can be increased by blowing hot air through it, rendering it particularly suitable for this purpose. Smaller quantities of rape oil are used for soft soap manufacture. In India the oil is largely used as an edible oil, in fact, it is said to be the chief oil used for cooking purposes (*Agric. Ledger*, 1911–12, p. 114); in Europe it does not appear to be used much as an edible oil, but refined rape oil is used as "bread" oil, *i.e.* for greasing the ends of loaves before baking (Lewkowitsch, *loc. cit.* ii. p. 256). Large quantities of rape oil are also

used in steel-plate manufacture, the heated steel plates being dipped in the oil in order to harden them. Most of the varieties of *Brassica campestris* resemble mustard (*Brassica nigra*), in that they yield ethereal mustard oil, to which the pungency of mustard is due, but in much smaller quantities.

The present price (September 1915) of crude brown East Indian rape oil, in Hull, is 36*s.* per cwt., and that of ordinary brown Japanese oil, in London, £34 to £36 per ton. The prices of various grades of Indian rape seed in Hull are as follows: Toria, 53*s.* to 53*s.* 6*d.* per quarter of 424 lb.; Ferozepore, 50*s.* to 50*s.* 6*d.* per quarter of 416 lb.; and Cawnpore, 52*s.* 3*d.* to 52*s.* 6*d.* per quarter of 416 lb.

Substitutes for Rape Seed

The seeds of several plants belonging to the Natural Order Cruciferæ yield oils similar in character to rape oil, and some of these enter into commerce in competition with true rape seed. Of these mention may be made of ravison seed, the product of a species of *Brassica* occurring in the Black Sea district of Russia. The seeds contain 33 to 40 per cent. of oil, which has a higher iodine value than rape oil, and is not so suitable for lubricating purposes as the latter. Ravison oil was quoted in Hull in July 1914 at 25*s.* 9*d.* per cwt. when crude brown East Indian rape oil was quoted at 28*s.* 3*d.* per cwt. The price of the seeds at that time was 31*s.* 3*d.* to 32*s.* per 424 lb., with Indian rape seed at about 50*s.* per 416 lb.

The seeds of "taramani" (*Eruca sativa*) are also imported to this country in small quantities under the name of jamba seeds. The plant is a native of Southern Europe and North Africa, and is extensively cultivated as a cold-season crop in Upper India, being usually grown in the latter region mixed with gram or barley, and sometimes with cotton. Most of the seed grown in India appears to be utilised in that country, the oil being used mainly for burning and to some extent for food, but it is exported to some extent from Karachi. A sample of the seed from India was examined at the Imperial Institute recently, and

was found to yield 30·8 per cent. of oil similar in character to rape oil (this BULLETIN, 1913, **11**, 562). Owing to the low yield of oil as compared with rape seed, the seeds are less valuable than the latter, the price in Hull in July 1914 being 38*s*. to 39*s*. per 424 lb. as compared with about 50*s*. per 416 lb. in the case of Indian rape seed. The oil, however, realises the same price as brown East Indian oil.

The analytical constants of ravison and jamba oils are shown in the following table:

	Ravison oil.[1]	Jamba oil.[2]
Specific gravity at $\frac{15·5° C.}{15·5° C.}$	0·9146 to 0·9204	0·915
Acid value	—	2·4
Saponification value	172·9 to 178·5	175·7
Iodine value . . . *per cent.*	115·2 to 120·4	101·6

[1] *Lewkowitsch, loc. cit. p.* 242. [2] *This* BULLETIN (1913, **11**, 562).

Rape-seed Cake and Meal

The residues remaining after the expression or extraction of oil from rape seed have a fairly high nutritive value. The following table shows the composition of rape-seed cake and meal compared with that of linseed and decorticated cotton-seed cakes:

	Rape seed cake (expressed).	Rape seed meal (extracted).	Linseed cake (expressed).	Decorticated cotton-seed cake (Atlantic ports) (expressed).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	7·7 to 9·9	10·2	11·6	7·40
Crude proteins	32·9 to 37·3	40·3	29·5	42·37
Fat	9·3 to 13·3	2·9	9·5	10·16
Starch, etc.	23·5 to 29·7	33·5	35·5	25·86
Crude fibre	5·9 to 10·9	8·4	9·1	7·06
Ash	6·4 to 12·8	4·7	5·2	7·15
Food units	135 to 155	141	133	157

Rape-seed cake is now used as a feeding stuff in this country to a less extent than formerly. This appears to be due partly to disrepute owing to adulteration, and largely to the fact that rape cake is liable to contain mustard seed, which produces injurious effects when fed to animals, owing to the presence of ethereal mustard oil.

A fairly large amount of rape-seed cake is said to be used in compound cakes, while the use of rape-seed cake for feeding purposes is stated to be extensive on the Continent. The principal use of the cake, however, is as a manure, generally in the form of meal from which almost all the oil has been extracted by means of solvents. Rape-seed meal contains about 4·9 per cent. of nitrogen (N), 2·5 per cent. of phosphoric acid (P_2O_5), and 1·5 per cent. of potash (K_2O), and forms an excellent manure for wheat or barley, while it is also used for potatoes and other root crops, and forms a favourite manure for hops. The price of rape-seed cake is generally about £2 per ton.

The Trade in Rape Seed, Oil, and Cake

As mentioned previously in this article, India is the chief source of supply of rape seed; in India the chief markets for the seed are Cawnpore and Ferozepore, the seed being shipped from Bombay, Karachi, and Calcutta. The following table shows the amounts and value of seed exported in recent years, together with the chief countries of destination:

Exports of Rape Seed from India

To	1911–12.		1912–13.		1913–14.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	384,571	176,084	427,892	228,419	281,984	179,830
Germany . .	811,919	403,772	1,094,247	599,897	1,163,973	650,734
Belgium . .	2,011,618	1,015,794	1,650,186	910,322	1,977,378	1,130,810
France . .	1,202,252	597,399	1,062,874	598,294	1,078,863	612,184
Italy . . .	117,595	58,457	58,263	31,620	274,537	163,074
Austria-Hungary	80,549	41,964	24,932	13,837	109,446	65,665
Other countries .	101,035	47,914	38,195	21,064	93,919	49,414
Total . .	4,709,539	2,341,384	4,356,589	2,403,453	4,980,100	2,851,711

Most of the Indian rape seed is produced in Sind, the quantity from this province exported in 1913–14 being 3,778,339 cwts., whilst 1,044,598 cwts. came from Bombay and 157,163 cwts. from Bengal.

The country of next importance to India as a producer of seed is European Russia, whence the following quantities have been exported in 1911–1913:

Exports of Rape Seed from European Russia

		1911.	1912.	1913.
Quantities . .	*cwts.*	1,783,220	2,400,640	2,675,260
Value . . .	£	798,095	1,137,142	1,161,979

Large quantities are also exported from China. Exact statistics are not available, as a certain quantity of mustard seed is included in the returns under rape seed, especially from the northern ports. The quantity and value of "rape seed" (including re-exports) shipped from China in recent years have been as follows:

Exports of Rape Seed from China

		1911.	1912.	1913.
Quantity . .	*cwts.*	356,261	959,563	734,254
Value . . .	£	148,571	382,600	293,395

Of these quantities nearly one-half went to Japan in 1913 and about one quarter to France.

The importance of the rape seed and oil industry in the United Kingdom is evident from the following statistics of imports:

Imports of Rape Seed to United Kingdom

From	1911.		1912.		1913.	
	quarters.[1]	£	*quarters.*[1]	£	*quarters.*[1]	£
India . . .	132,710	256,045	70,123	166,077	96,497	221,231
Russia . . .	84,485	140,026	90,456	151,074	116,440	194,617
China . . .	12	20	8,916	20,849	32,880	69,866
Other countries. .	14,992	35,285	17,773	38,939	19,743	46,011
Total . . .	232,199	431,376	187,268	376,939	265,560	531,725

[1] 1 *quarter of rape seed* = 416 *to* 424 *lb. according to country of origin.*

Imports of Rape-seed Oil to United Kingdom

From	1911.		1912.		1913.	
	tons.	£	*tons.*	£	*tons.*	£
Germany . .	3,468	100,509	1,870	58,139	1,539	47,707
Netherlands . .	1,890	58,965	1,439	47,951	903	29,118
Belgium . . .	1,907	55,054	2,743	81,636	1,884	55,441
France . . .	265	8,019	431	13,101	366	10,770
Japan . . .	185	5,308	1,184	33,661	2,786	75,791
Other countries. .	693	18,338	613	18,138	121	3,729
Total . . .	8,408	246,193	8,280	252,626	7,599	222,556

Fairly large but fluctuating quantities of rape-seed cake are imported to the United Kingdom. Most of this comes from Russia, as is shown in the following table:

Imports of Rape-seed Cake to the United Kingdom

From	1911.		1912.		1913.	
	tons.	£	*tons.*	£	*tons.*	£
Russia . . .	43,481	183,043	14,293	72,554	25,839	139,711
Other countries . .	7,610	29,661	2,313	13,335	3,043	16,881
Total . . .	51,091	212,704	16,606	85,889	28,882	156,592

In view of the fact that our supplies of seed, oil, and cake are in large measure derived from foreign countries, and as rape seed is one of the few oil seeds which can be grown both in the United Kingdom and in various parts of the Empire, it would be well worth while to attempt its cultivation in British territories where at present it is not grown, especially as the demand for the seed is fairly large and constant.

THE SOURCES OF SUPPLY OF ALMONDS

THE common almond tree, *Prunus Amygdalus*, Linn. (= *Amygdalus communis*, Stokes), is a member of the Natural Order Rosaceæ. Other important and closely allied members of the genus *Prunus* are the apricot and the peach, which closely resemble the almond, one of the principal differences being found in the pericarp of the fruits, which in the case of the apricot and peach is fleshy, but in the almond is dry and woody.

The almond tree is small, rising usually to a height of from 15 to 25 ft., and dividing into numerous spreading branches. The leaves are lanceolate and serrated. The flowers are large, of a pale red colour varying to white, and usually occur in pairs. The fruit is a drupe of ovate form, covered with a green downy epicarp. The mesocarp is tough and dry and surrounds the rough shell containing the kernel or almond, which is covered with a brown testa, varying in thickness according to the variety. The epicarp

is marked with a longitudinal furrow along which the fruit opens when fully ripe.

All almonds fall within one or other of two classes, and are known as sweet or bitter almonds according to the taste of the kernel. Fruits belonging to these two classes are designated as *Amygdalus communis dulcis* (sweet), and *A. communis amara* (bitter), although hitherto no botanical difference has been found to exist between either trees or fruits of these two classes. It seems probable that in its original state the almond was a bitter variety, and that the sweet variety, occurring first as a "sport," became established by cultivation.

De Candolle considers the almond to be indigenous to an area extending from Persia westwards to Asia Minor, Syria, and, perhaps, part of Greece. The tree has been cultivated since very early times, one of the first references to it being found in the Old Testament. Even at the present day a truly wild bitter almond tree is stated to occur throughout Palestine in such numbers that the kernels form an article of commerce, being collected by the Bedouin women and taken into Damascus (*Bulletin* No. 180, *Bur. Plant. Ind.*, *U.S. Dept. Agric.*, p. 15).

The most important almond-producing countries are Spain, Portugal, Morocco, Sicily, France, Canary Islands, Italy, Sardinia, Syria, Persia, and Southern California. The almond was introduced into the latter country in 1885, and since then has been grown quite successfully. It is stated that the cultivation of almonds in California has now become distinctly profitable in certain valleys of the State, although difficulty has been experienced in finding localities whose climatic conditions are adapted for almond culture.

Sweet almonds are cultivated principally in Spain and Southern California. The Spanish industry is centred in the districts around Malaga, Valencia, and Alicante. French almonds are grown in Provence, the chief marketing centre being the town of Aix. Italian almonds are produced mainly in Sicily and the districts round Bari. Of late years, owing to the rise in prices, almond cultivation has been taken up in Sardinia. Both sweet and bitter varieties are grown, and the total crop for an average

season is stated to be about 1,000 tons. Bitter almonds are obtained very largely from North Africa, particularly Mogador.

Numerous varieties of the almond, especially of the sweet almond, are known, which differ principally in the thickness of the shell, delicacy of flavour of the kernel, and thickness of the testa. Some of the best-known European varieties are the Jordan, Valencia, "Princess" (remarkable for its very thin shell), Languedoc, "Douce à coque dure," "Sultana," and Pistache. Varieties cultivated in California are the "Excelsior," "Non plus ultra," "Nonpareil," "Il Suprama," and "Commercial."

Climatic Conditions

The almond tree flourishes best in subtropical regions which possess a small but sufficient rainfall, and where nothing more than a very slight frost is experienced during the flowering season (January or February). It also grows well in the warmer districts of the temperate zone, but here the yield of fruit is always uncertain, as the winter climate is usually more severe, and the almond blossoms, owing to their habit of appearing early in the year, are exposed to the risk of being injured by frost. In the tropics, the almond tree, whilst apparently flourishing, usually becomes partly or wholly sterile, owing to the excessively moist climate.

In the vicinity of Malaga in south-eastern Spain, where the most valuable almonds of commerce, the well-known Jordan almonds, are grown, the climatic and other conditions are apparently ideally suited for the cultivation of this variety, since it cannot be grown with equal success in any other district of Europe. It is stated, however, that owing to bad seasons and fungoid diseases, Malaga now occupies only a secondary place in almond culture. Valencia almonds, which rank next in quality to the Jordan variety, are grown over a much larger area, comprising all the southern and eastern coasts and several other districts in Spain, but the Jordan almond is only found in a small district which commences at Malaga and

continues for about a hundred miles to the east, varying in depth from three to forty miles. The climate of this district is sub-tropical, the date-palm and sugar-cane both growing in the open air. The date-palm grove at Elche is the only one in Europe which produces edible, though not excellent fruit. Slight frosts usually occur in December, but at this time of year the almond tree is not yet in blossom, so that, as a rule, no injury results to the fruit. The rainfall, too, is small, and apparently suited to the requirements of the tree. The months of July, August, and September are stated to be practically rainless, whilst the winter rains are infrequent and scanty.

Soil

The almond tree flourishes best in a deep, warm, dry, and, if possible, very chalky soil, preferably on the slope of a hill, as this can be made to afford some shelter from the prevailing wind, and also lessens to a certain extent the liability to damage by frost. The best land for almonds in Spain is stated to be that of the sierras round Malaga and Alicante. This is a gravelly loam, which becomes very dry during August, and breaks up into irregular but not very hard lumps.

Cultivation

Most of the almond trees in Spain are either budded or grafted, the stock employed being usually of the bitter variety. The finest almonds are selected and placed in layers in wet sand in the autumn. In the following spring they are sown about 2 in. deep in light, rich soil, being placed about a foot apart with a space of 2 ft. between the rows. At the end of the same summer the young plants may be budded with a dormant bud about 3 in. above the surface of the ground. As a rule, however, the almond is trained as a standard or half standard, in which case the seedlings are allowed to grow for a year or two longer, when they are grafted at a height of from 2 to 4 ft. above the ground. In the spring following the budding or grafting the young trees are cut back and planted out in

their permanent situation in the orchard, a space of about 15 ft. in every direction being the most suitable distance.

In Spain the trees are often planted at as great an interval as 20 ft.: this is apparently rendered necessary by the longevity of the trees, which frequently reach an age of fifty years with corresponding increase in size.

The subsequent treatment of the tree is similar to that given to the apricot. In order to obtain good crops the tree must be pruned yearly and kept well manured.

The method of harvesting is very simple. When the fruit is ripe the pericarp opens, the almonds are knocked off with light rods, the nuts separated from the dry pericarp and spread out to dry. They are either exported in the shell or else cracked by hand, usually by women and children. In the latter case the kernels are taken down from the villages to the local buyers, who send them to the shipping warehouses, whence they are exported after having been carefully graded.

In Italy, it is stated, the almond begins to bear at four years old, and reaches full bearing at about fifteen years. The average yield of an almond tree is stated to be about 9 lb. of shelled almonds, where soil and climatic conditions are in every respect favourable. The cultivation of sweet almonds is stated to be more remunerative than that of almost any other crop, since the demand for this variety is somewhat greater than for the bitter almond, and their cultivation is confined to such a comparatively limited region.

The following table shows the imports of almonds into the United Kingdom during recent years, together with the countries of origin:

From	1911.		1912.		1913.	
	cwts.	£	*cwts.*	£	*cwts.*	£
France	7,254	29,557	5,222	20,430	4,937	21,575
Portugal	20,944	91,289	7,945	33,412	12,747	71,901
Spain	98,230	486,679	71,104	352,373	66,915	381,913
Canary Islands	7,588	36,395	4,399	21,038	5,237	33,248
Italy	16,097	76,787	32,907	157,864	19,862	102,454
Morocco	36,968	177,729	30,400	148,238	37,422	217,621
Other countries	12,396	55,043	10,407	37,962	10,677	59,426
Total	199,477	953,479	162,384	771,317	157,797	888,138

In 1914 the total imports of almonds into the United Kingdom amounted to 114,578 cwts., valued at £656,829.

The exports of almonds from the principal countries of production are as follows:

	Quantities in cwts.		Value.	
	1911.	1912.	1911.	1912.
			£	£
Italy	365,600	452,600	1,600,000	2,062,000
Spain	291,260	185,600	1,048,000	635,000
Morocco	56,540	42,280	232,124	169,481
California	—	60,000	—	—

The United Kingdom and the United States are almost the only consuming markets for Jordan almonds. The United Kingdom takes the bulk of the larger fruit, whilst the United States buys all the small.

Utilisation of the Fruit

Both sweet and bitter almonds contain a fatty oil which is largely used in commerce. In addition, a volatile oil is manufactured from bitter almonds, although it does not occur naturally in the kernel, but is produced by decomposition of a glucoside which is not found in the sweet almond.

Sweet almonds are principally used in confectionery in various forms, or else are eaten alone as a dessert fruit, etc. For edible purposes the brown testa of the kernel is sometimes removed, and the product is then known as "blanched almonds." A number of substitutes for the sweet almond are now employed for some of these purposes, among which may be mentioned pistachio nuts (the product of *Pistacia vera*, Linn., Nat. Ord. Anacardiaceæ), and peach and sweet apricot kernels; while in recent years blanched ground nuts which have had their characteristic flavour removed and almond flavour added have been used. The bitter almond is usually employed for expressing almond oil.

Fixed Oil.—The sweet almond usually contains 44 to 55 per cent. and the bitter 38 to 45 per cent. of oil. Both varieties

were formerly employed for the preparation of almond oil, the oils from both sources being practically identical, but owing to the advance in price of sweet almonds, and also to the fact that the volatile oil can only be prepared from bitter almond cake, the latter variety is now usually the only one used. Lewkowitsch (*Chem. Technology of Oils, Fats, and Waxes*, 1914, vol. ii. p. 287) states that almond oil is as a rule manufactured in this country from Mogador bitter almonds, which are always more or less mixed with sweet almonds.

Almond oil is a clear, bright yellow, practically odourless oil, which only solidifies at a temperature of $-15°$ C. The following table shows the usual range of the constants of the oil (Lewkowitsch, *loc. cit.*):

Specific gravity at $\frac{15° C.}{15° C.}$ . . .		0·917 to 0·919
Saponification value		189·5 to 195·4
Iodine value . . .	*per cent.*	93 to 101·2
Solidifying point of fatty acids . .		9·5 to 11·8° C.

Almond oil is extensively employed in pharmaceutical practice in the preparation of emulsions, ointments, etc., and also as a vehicle for the administration of other medicinal agents. Owing to the continued rise in price of almonds, the oil is at the present day very much adulterated with, or often completely substituted by, apricot- and peach-kernel oils. As early as 1889 it was stated by a German firm that fixed oil of almonds was generally represented on the market by peach-kernel oil. Since then stricter enforcement of the food laws by various countries has tended somewhat to minimise flagrant adulteration, but almond oil substitutes are being at present manufactured in large and increasing quantities from apricot and peach kernels, obtained chiefly from Syria and California. Oil obtained from these sources is sold commercially as "oleum amygdalæ persicæ," *Amygdalus persica* (*Prunus persica*) being the botanical source of peach kernels. The analytical constants of apricot- and peach-kernel oils are shown in the following table (Lewkowitsch, *loc. cit.* pp. 281, 286):

	Apricot kernel oil.	Peach kernel oil.
Specific gravity at $\frac{15 \cdot 5^\circ C.}{15 \cdot 5^\circ C.}$.	0·9172 to 0·9200	0·9198
Saponification value . .	188 to 198·5	189 to 192·5
Iodine value . . *per cent.*	96·02 to 108·7	92·5 to 110·1

Bitter-almond Oil.—The volatile oil or essence from bitter almonds is prepared from the cake left after cold expression of the fixed oil. The press cakes are finely ground, mixed with 6–8 parts of water at 50°–60° C., and allowed to stand for about 12 hours. Both sweet and bitter almonds contain a ferment, emulsin, but in addition bitter almonds contain a glucoside amygdalin. During the grinding of the cake the vegetable cells are ruptured and the emulsin and amygdalin are brought into contact in the presence of water. Under these circumstances the amygdalin is rapidly decomposed by the emulsin into glucose, hydrocyanic acid and benzaldehyde, the last of these being bitter-almond oil. The oil separates from the ground-up mass, and being volatile can be distilled off in steam. Oil prepared in this fashion still contains hydrocyanic acid (prussic acid), which is poisonous, and to remove this it is shaken up with lime and ferrous sulphate and again distilled in steam. This process is stated to remove all traces of hydrocyanic acid. The yield of volatile oil amounts to 0·5–0·7 per cent. of the whole almond.

As prepared by this method, bitter-almond oil is a colourless liquid, of sp. gr. 1·050–1·055, b.p. 179° C. It oxidises quite readily on exposure to air, depositing crystals of benzoic acid.

According to the German chemists Gildemeister and Hoffmann (*The Volatile Oils*, p. 437) only a very small amount of the bitter-almond oil of commerce is prepared from bitter almonds. Most of it is stated to be manufactured from peach and apricot kernels, the oil so obtained being practically identical with genuine bitter-almond oil. This is particularly the case with the oil made on the Continent.

Synthetic benzaldehyde is sometimes used as a substitute for bitter-almond oil, but as it usually contains chlorinated products possessing an unpleasant odour and

taste, it can be employed only as a cheap perfume for soaps, etc.

The natural oil is largely used in perfumery, and also as a flavouring agent in confectionery, liqueurs, etc.

Almond Meal.—According to Lewkowitsch the meal left after expression of the oil from *sweet* almonds is used in confectionery, and also in the manufacture of certain toilet preparations. The residual meal in the case of bitter almonds is employed, as already stated, for the manufacture of essential oil of bitter almonds.

TRADE AND INDUSTRIES OF SEYCHELLES

The following particulars taken from the Report of the Collector of Customs on the Trade of Seychelles for 1914 are published with the sanction of the Colonial Office:

The total value of the imports in 1914 was Rs.1,445,648, as against Rs.1,279,942 in the previous year. The principal items were as follows: Foodstuffs, Rs.586,676, including rice to the value of Rs.348,806 from India; cotton goods, Rs.167,340, about half of which came from the United Kingdom; spirits, wine, and beer, Rs.87,370; machinery, Rs.65,675, being Rs.31,795 more than in 1913; sugar, 263,875 kilograms, received entirely from Mauritius, a decrease of 79,153 kilograms as compared with the previous year; coal, 3,797 tons valued at Rs.58,140; haberdashery, Rs.44,813; hardware and ironware, Rs.37,129; boats and accessories, Rs.26,247; soap, Rs.19,619, chiefly from the United Kingdom; petroleum, Rs.17,509, from the United States; whaling gear, Rs.13,357; tobacco, including cigars and cigarettes, Rs.12,354.

The total value of the exports in 1914 amounted to Rs.2,115,903, showing a decrease of rupees 368,299 as compared with the previous year. The principal commodities which show increases were coconuts, copra, coconut oil, vanilla, essential oils, calipee, and shark-fins. The chief articles showing decreases were guano, cinnamon bark, coco-de-mer, whale oil, rubber, and caret shells. The quantities and values of the chief articles exported in 1913

and 1914, and the countries of destination in the latter year, are shown in the following table:

	Unit.	Quantity. 1913.	Quantity. 1914.	Value. 1913.	Value. 1914.	Country of destination in 1914.
				Rs.	Rs.	
Copra . .	cwts.	58,865	72,546	1,080,736	1,185,820	France, Belgium, United Kingdom, and Germany.
Guano . .	cwts.	694,400	372,140	1,041,600	558,210	United Kingdom, Holland, Mauritius, and Germany.
Vanilla . .	cwts.	120	210	101,847	131,730	United Kingdom chiefly.
Cinnamon bark	cwts.	13,962	11,805	53,305	44,649	Germany, Holland, United Kingdom, and Austria.
Coconut oil .	gallons	10,697	15,906	25,604	35,454	Reunion, Madagascar, Mauritius, and Aden.
Essential oils	gallons	924	1,870	16,482	35,325	Germany, United Kingdom, and France.
Caret shells .	cwts.	34	12	63,633	23,074	United Kingdom, Germany, and France.
Calipee . .	cwts.	114	179	16,501	20,094	United Kingdom and Germany.
Soap . .	cwts.	1,271	975	23,288	18,720	French and German Colonies.
Coconuts .	number	103,350	173,102	5,473	8,413	Mauritius, Aden, French Colonies, United Kingdom, etc.
Rubber . .	lb.	1,768	1,058	4,165	2,360	United Kingdom.
Coco-de-mer	number	3,515	2,746	2,846	2,355	India and Mauritius.
Salted fish .	—	—	—	7,422	1,882	Reunion.
Boats and accessories	—	—	—	13,975	1,560	Madagascar and East Africa Protectorate.

It is interesting to note that the exports of the products of the coconut palm continue to increase, in spite of the fact that during August and September the export of copra was at a standstill owing to the war.

The guano industry was affected to a greater extent than any other by the European crisis, no guano being exported to Europe after the outbreak of war.

Although there was a considerable increase in the quantity of vanilla exported as compared with the previous year, the prices obtained were low, and the exports were considerably less than the record year of 1907, when 1,307 cwts., valued at Rs.996,900, were shipped.

The essential oil industry again shows a considerable increase in production, the quantity exported being more than double that of 1913, with a marked increase in value. In addition to cinnamon leaf, clove leaf, and lemon grass oils, vetiver root oil figures in the exports for 1914.

No whale oil was exported, but whaling operations were re-commenced in the middle of October, and up to the end of the year 47 whales had been caught. A factory was erected during the year on St. Anne Island, and machinery has been installed for the manufacture of whale manure. A whaling licence was issued to a second company, but they had not commenced operations at the close of the year. Regulations were issued making it illegal to shoot or kill any whale calf or any female whale accompanied by a calf.

NOTES

The War and New British Industries: Imperial Institute Monographs.—*Oil Seeds and Feeding Cakes.*—Reference has already been made in this BULLETIN (1914, **12**, 458, 557) to the effect of the war on the trade in palm kernels and copra, which have hitherto been exported in large quantities from British Possessions to foreign countries, and especially to Germany. Other oil seeds exported largely from British Possessions include ground nuts, sesame seed, and mowra seed, and the trade in these also has been greatly affected by the war. In order to direct the attention of merchants, manufacturers, agriculturists and others, to the importance of the oil seeds mentioned, with a view to their utilisation in this country as sources of oil and feeding cake, a volume entitled *Oil Seeds and Feeding Cakes* has just been published by Mr. John Murray as the first of a series of Imperial Institute Monographs dealing with the War and New British Industries. The book, which contains a preface by Professor Wyndham R. Dunstan, C.M.G., LL.D., F.R.S., Director of the Imperial Institute, is written in popular language, and gives full statistical information regarding the trade in each product, the industrial uses of the oils, and particulars as to the feeding values of the cakes. These monographs will be sold at 2*s.* 6*d.* net per volume.

The World's Supply of Potash.—For many years past the world's supply of potash has been in German hands owing to the fact that Germany possessed the enormous potash deposits of Stassfurt, which could produce potash more cheaply than any other locality in the world. The seriousness of this position is evident, since potash is an indispensable constituent of manures, without which modern agriculture could not be continued. In this respect the supply of potash is a matter which concerns everyone. Similarly, many British chemical industries, such as the

manufacture of soft soap, alum, bichromates, glass, etc., depend for their continuance on supplies of potash.

In spite of the German potash monopoly the manufacture of potash compounds from other sources has lingered on in a small way in Scotland, Norway, France, Japan, Russia, and elsewhere, and in the last few years Italy and the United States especially, have endeavoured to utilise new sources under their own control. Quite recently new deposits of salts somewhat of the Stassfurt type have been discovered in Spain and India. All these sources of potash and the methods of utilising them are dealt with in a pamphlet just issued by the Imperial Institute entitled "The World's Supply of Potash," which is intended mainly to direct the attention of manufacturers and others interested to hitherto unutilised sources of supply of potash.

The pamphlet may be obtained on application to the Imperial Institute, South Kensington, price 1*s*. post free.

New Varieties of Indian Wheat.—With a view to improving the quality of the wheat produced in India experiments have been conducted there by the Imperial Economic Botanist for several years past at the Agricultural Research Institute, Pusa. By the application of modern methods of selection and hybridisation high grain qualities, *i.e.* in respect of milling and baking, have been successfully combined with high yielding power, rust-resistance, and strong straw, so that varieties have been found which gave, on land with fair cultivation, upwards of 2,500 lb. of grain to the acre without irrigation. Mr. A. E. Humphries, past President of the Incorporated Society of British and Irish Millers, has conducted milling and baking tests with these new Pusa wheats, and reports that they are a great advance on those hitherto exported from India, and that they behave in the mill and bakehouse like Manitoba spring wheats, which are in greatest demand for bread-making in this country and command the highest prices on the home markets. Enquiries made in India have shown that the cultivators, land-holders, and educated community prefer the Pusa wheats for their own food to those ordinarily grown in India.

One of these new wheats, known as Pusa 12, has been shown to be the best for general cultivation both in the Gangetic plain and also on the black soils of Peninsular India. This wheat has invariably given the highest yield not only in almost every district from Gurdaspur in the Punjab through the United Provinces to Bhagalpur in Bihar, but also on the black soils in Bundelkhand and in the Central Provinces (*Rep., Agric. Res. Instit. and Coll., Pusa*, 1913–14, p. 33). At the same time it has been demonstrated that its milling and baking qualities have

been maintained unimpaired, both under "barani" conditions, *i.e.* on land dependent for its water solely on rain, and also under canal and well irrigation. When placed on the Calcutta market for the first time in 1913-14 this wheat found a ready market at the mills, and fetched 4 annas a maund, that is about 2*s.* per quarter, above Bihar wheats on its appearance alone. Pusa 12 is being distributed to cultivators in the United Provinces, the Punjab, Bihar, and Central Provinces, and in 1913-14 the supply was found to be far below the demand.

Mr. Humphries, at the request of the Indian Government, has recently called the attention of millers in this country to the quality of Pusa 12 at a general meeting of the National Association of British and Irish Millers (*Milling*, 1915, **44**, 656). He states that in order to give millers an opportunity of testing this wheat, so that they will be in a position to know its qualities and true commercial value when it is offered them in commercial quantities, 30 tons are being shipped to this country. His firm will clean, condition, and mill the wheat separately, and any miller can obtain from him 4 or 7 lb. samples of the wheat and the flour gratis, while larger quantities, up to a few sacks, can be purchased. He is also willing to supply millers with particulars as to various technical points upon which they are likely to be interested.

Another variety, known as Pusa 4, is also being grown on a large scale. It has a blemish in the shape of a black spot at the germ end of the grain, but Mr. Humphries states that this is of no technical importance, and the quality is first class. This wheat is more particularly suited for cultivation in the districts in India where the water supply is short. At present no shipments are being made, so that this wheat is not yet available for commercial trials in this country.

Mr. Humphries sums up by saying that "these new wheats are something essentially and totally different from the ordinary Indian wheats of commerce, and very much superior to them. They behave very well indeed in conditioning and milling. As regards quality they are a very close approximation to Manitoba wheats, though they are white wheats." He points out, however, that in order to obtain loaves of normal size he has found it desirable to use diastatic extracts in baking, for by this means a sufficiency of gas is ensured during all stages of fermentation; but as this process is very well known to bakers and to a less extent to millers, it should have no influence on the reception accorded to these wheats by British millers.

Dura for Bread Making.—In Egypt, the Sudan, and other parts of Africa, where dura (*Sorghum vulgare*) is largely grown, it is the staple food of the people. It is also used

for feeding cattle and poultry, and for a variety of other purposes. Its possible uses in Europe have been dealt with already in this BULLETIN (1911, **9**, 253; 1913, **11**, 33); in the present note it is proposed to deal with its use for bread making. In a pamphlet published recently by the Ministry of Agriculture, Egypt (*Egyptian Agricultural Products*, No. 1A, p. 22), and dealt with more fully subsequently in this BULLETIN (p. 482), an account is given of the preparation of dura bread in Upper Egypt, where this crop is the chief source of flour. For bread making it is almost always used in combination with either wheat, barley, fenugreek, or even beans.

In an article in *L'Agricoltura Coloniale* (1915, **9**, 217) a summary is given of experiments in bread making with dura that have at various times been carried out in Italy. Results of experiments in which dura was used alone and in admixture with wheat in various proportions are tabulated, and analyses are given of bread made with dura, and with various mixtures of dura and wheat, in comparison with those of bread made from wheat and other cereals. Analyses are also given of dura flour prepared from the grain produced in various countries, together with corresponding figures for the flours of wheat, rye, maize, and barley. These figures show the high nutritive value of dura, and are of especial interest at the present time in view of the high prices of wheat and cereals generally.

Bread made from dura flour with an admixture of 25 per cent. of wheat flour had all the desirable qualities of good bread; its taste was excellent, and superior to that of bread made from wheat flour in admixture with rye, rice, or potato flours. Bread made from dura flour alone was of excellent quality and taste, and had several points of superiority over bread made from rye or maize. Such bread, made by European methods, is of course quite different from the dura bread made by the methods in vogue in Egypt and in other parts of Africa.

The cultivation of dura in Italy in place of maize has been suggested, and has been tried already on an experimental scale. The chief objection to this crop is its late ripening, but it is anticipated that this disadvantage may be minimised by limiting its cultivation to the southern parts of the country or by planting comparatively early-ripening varieties; it is also hoped that improvements may be effected in this and other respects by means of selection.

The Indian Sugar Industry.—India is the largest producer of cane sugar in the world, and, at the same time, the largest consumer. Her production is not, however, sufficient for her own requirements, and sugar to the value of nearly £10,000,000 annually is imported, mainly from Java.

The following table shows the imports of sugar into India during the years 1912–13 and 1913–14:

From	1912–13.		1913–14.	
	cwts.	£	cwts.	£
Mauritius	3,107,970	2,148,819	2,847,918	1,676,333
Austria-Hungary . .	1,051,779	711,458	1,480,218	922,460
Java	10,957,862	6,294,535	13,406,667	7,096,335
Other countries. . .	325,452	364,360	202,587	276,123
Total	15,443,063	9,519,172	17,937,390	9,971,251

The following table shows the exports of sugar (Indian merchandise) from India during the same years:

To	1912–13.		1913–14.	
	cwts.	£	cwts.	£
United Kingdom . .	226,188	110,341	94,461	30,757
Ceylon	50,968	21,740	50,022	22,321
Other countries. . .	42,994	37,699	47,447	38,571
Total	320,150	169,780	191,930	91,649

It is believed that India might not only grow and manufacture sufficient sugar for the needs of her own population of 320,000,000, most of whom are large consumers of sweetmeats, thus saving her expenditure of £10,000,000 on imported sugar, but also ultimately produce a large surplus for export, and become a source of supply of sugar to the United Kingdom.

Furthermore, if India were self-supporting as regards sugar production, the sugar grown in Mauritius, which at present is almost entirely shipped to India, would become available for importation to the United Kingdom.

Java sugar has gained its strong position in India owing to the favourable conditions for cheap production in Java, the use of modern machinery, methods of manufacture and factory organisation, and the attention which is given there to the utilisation of the by-products of sugar manufacture.

For the expansion of sugar production in India, the most important desiderata are the study of the best canes to grow from the point of view of high yield of sugar and suitability to local conditions of soil and climate, the improvement of manufacturing methods, and the adoption of the most modern machinery.

If large central cane factories are to be made to yield good profits in India, development must be along the lines of intense cultivation, and cultivators must be induced to grow more cane per acre with an increased yield of sucrose per acre. In the past the manufacturing side of sugar production in India has been studied more than the agricultural side. It is now realised that problems of

cultivation, manuring, and irrigation are of equal importance to any that arise in the sugar factory.

Mr. W. Hulme has contributed a paper to the *Agricultural Journal of India* (1915, **10**, 54) on the improvement of sugar production in India, particularly in the United Provinces. Java possesses several advantages over India in the matter of cane cultivation, but the only one which is not remediable is that of climate, which in Java is better suited for cane growing than in the United Provinces. On the other hand, the freight charges from Java to India, which amount to about 50*s.* a ton, tend to neutralise the advantages possessed by Java sugar. In Mr. Hulme's opinion, India should follow the example of more successful cane sugar producing countries by eliminating the small and costly establishment and concentrating the production of the finished article in large factories capable of turning out 12,000 maunds (about 450 tons) of sugar a day. To achieve this, negotiation and organisation will have to be carried out with the native cultivators to ensure that enough cane is grown within reasonable distance of the factory and is cut at the right time to prevent wastage and loss.

The multiplication of large factories may take many years to accomplish, and in the meantime progress might be made by inducing cultivators to combine on a co-operative basis and start a power-mill to take the place of native bullock mills. Mr. Hulme suggests that a triple mill (nine rollers with crusher) extracting 90 per cent. would give the best results; failing that, a six-roller mill with an extraction of about 80 per cent. would serve. The capacity would be about 10 tons of cane a day. This mill would not make sugar to compete with the foreign article, but would supply a good class of sugar for native consumption. A small modern power-mill and installation would also serve to educate the natives to the advantages of modern plant, and so pave the way to a readier acquiescence in the central factory system with its large areas of supply.

Some useful hints for Indian sugar producers are contained in *Notes on Sugar Machinery and Manufacture in Northern India*, 1914, by Peter Abel, Representative of the Harvey Engineering Company, Ltd., Glasgow, issued by the Agricultural Research Institute, Pusa. Mr. Abel visited a number of sugar factories in order to ascertain their requirements in regard to sugar machinery and to advise the Government of India in connection with sugar matters generally where such advice was desired. He mentions that buildings were solidly constructed, but in most cases insufficiently lighted. Insufficient lighting makes cleanliness, which is the first essential in a sugar factory, impossible. The approaches and exits seemed in most cases ill-arranged, resulting in confusion of carts and

animals delivering cane. Accumulations of cane in the yard prevented free movement of carts and the crushing of deliveries of cane in the order of their arrival.

Mr. Abel observes that unless the price of white sugar is far enough above that of second-quality sugar to compensate for a greater vacuum-pan capacity, extra centrifugal machines, and more fuel, as well as a decreased output, the maker who has a fair market for second sugar will be well advised to continue to make it.

With regard to the extraction of sugar, no figures extending over a number of years were obtained, but he states that the condition of the cane yards, the poor crushing, the inferior appliances for treatment of the juices, and the shortcomings of the crystallisers, taken together, are sufficient to show that the output cannot be satisfactory.

Mr. Abel concludes that, with a few modifications and additions, there is no reason why the Indian factories inspected by him should be far behind those of Java in the matter of sugar extraction.

Cotton Breeding in the United Provinces, India.—An interesting paper on "The Breeding of Improved Cottons in the United Provinces" has been contributed by H. Martin Leake, M.A., Economic Botanist to the Government, United Provinces, to the *Agric. Journ. of India* (1915, **10**, 111). In the first place the various characters required in an ideal cotton plant for the United Provinces are considered. The climatic conditions demand that the plant should be an early maturing form. From the point of view of the cultivator, it is desirable that an improved cotton should give an increased yield per acre, and that the value of the crop should also be enhanced by an improvement in the quality of the product. The yield of lint per acre depends both on the production of "kapas" (seed-cotton), and on the percentage of "rui" (lint) in the "kapas," or, in other words, the ginning yield. The yield per acre is controlled largely by the type of branching and the size of the bolls, whilst the ginning percentage depends chiefly on the number of fibres arising from a single seed and to a smaller extent on the size of the seed and the weight of the individual fibres. From the standpoint of the manufacturer, the chief qualities to be considered are the length, twist, fineness, colour, and uniformity of the cotton, and its freedom from nep and extraneous matter.

After considering these characteristics of the ideal cotton plant, the author reviews the material available for the production of such a plant by breeding experiments. The bulk of the commercial cotton crop of the United Provinces consists of "desi," a mixture of races of *Gossypium neglectum* (or *G. indicum*); many of these have a good

habit, and some of them give a high ginning yield, but, in general, they produce a short and coarse fibre. Another variety occurring here and there in the United Provinces is the so-called "nurma" cotton plant, *G. arboreum*; this variety has a perennial habit, and is therefore unsuitable for cultivation, and has a low ginning percentage; the fibre, however, is fully 1 in. long and moderately fine. The only other plant found in the United Provinces is the "radhiya" cotton (*G. intermedium*) of the Eastern districts, which is unsatisfactory in every way.

Among cottons grown in other parts of India are three which were regarded as worthy of consideration in connection with this work. They are (1) the "bani" cotton of Central India, which has a fine, long fibre, but gives a small yield and low ginning percentage; (2) the Broach variety, which flowers late and is therefore unsuitable for the United Provinces; and (3) the Garo Hill cotton (*G. cernuum*), which is of a robust and early habit, and gives a high ginning yield and particularly large bolls, but furnishes a very short, coarse fibre.

Each of the varieties mentioned is evidently far from possessing all the characteristics of the ideal plant, and it is clear that the latter can only be built up by combining the best characters of three or even more races. The ideal habit has been found only in one plant, a variety of the common "desi" kind. This plant is early maturing, and bears a profusion of vigorous, fertile branches; but the lint is little better than that of the ordinary "desi" mixture, whilst the ginning yield is about the same and the bolls are small. Pure cultures of this plant have been distributed, under the name of K 7, in Bundelkhand, for which district its early habit renders it particularly suitable. This plant, therefore, has been used as the basis of the ideal plant it is desired to obtain. High ginning yield may be derived from a "desi" type or from the Garo Hill cotton, and the latter may also be used for the production of large bolls. Length of fibre could be supplied from the "nurma" or the "bani" cotton, and the latter is the only form giving a fine, silky fibre.

New races of cotton have been established by hybridisation of (1) K 7 and "nurma," (2) a coarse "desi" variety of high ginning yield and "nurma," (3) "nurma" and "bani," (4) "nurma" and a white-flowered "desi" form, and (5) a "desi" cotton and the Garo Hill variety. These new races are described, and it is shown that none of them agrees in all respects with the ideal plant in view. This, of course, is only what would be expected, since each race is the result of a single cross. Further work, however, has resulted in the production of a cross between races (1) and (3) which has now been cultivated to the third generation. These plants contain in their parentage, the "nurma," "bani," and

K 7 cottons, and it is anticipated that a form will ultimately be selected from these which will approximate fairly closely to the ideal plant.

Another point which has been investigated is the production of a cotton bearing naked seeds. This is of importance, as the ordinary Indian cotton seed bears a coarse fuzz which depreciates its value as a cattle food, whether used either directly or in the form of oil-cake. The naked-seeded Egyptian and American forms will not hybridise with Indian races; but certain plants have been obtained recently from China which bear naked seeds, and are completely fertile when crossed with Indian "desi" forms. By this means robust races have been produced with a naked seed.

Cotton Problems in Italian East Africa.—The first attempts to cultivate cotton in Italian East Africa were made in Erythrea in 1904 (cf. this BULLETIN, 1914, **12**, 138), and in Italian Somaliland in 1906. In Erythrea only American cotton has been successfully grown; the cotton cultivated in that colony is of Upland Long Staple stock, but has become so modified as to be now regarded as a local variety. In Italian Somaliland both American and Egyptian cottons have been grown with success, and the many varieties available afford ample scope for selecting those best suited to the different parts of the country, which differ chiefly in respect of the important question of water supply. In that country, as in Erythrea, the technical difficulties in the way of cotton cultivation are small; the worst is that of insect pests, but these can be controlled in the countries under consideration as well as elsewhere. The economic difficulties are, however, very considerable, and these are treated at some length in *L'Agricoltura Coloniale* (1915, **9**, 193, 321), by Dr. G. Scassellati-Sforzolini and Dr. G. Mangano, who deal with Italian Somaliland and Erythrea respectively.

The economic problems fall under three headings: irrigation, means of transport and labour, and in each colony the Government is called upon to deal with these questions.

In Italian Somaliland the two chief rivers are the Juba and the Webi Shebeli; the former is the larger and is the boundary between the Italian colony and the British East Africa Protectorate. Both have periods of flood, but in order to enlarge the area watered a system of artificial irrigation by means of dams is necessary, and it is suggested that joint action should be taken by the British and Italian authorities in exploiting the Juba for the combined benefit of cotton cultivation on both sides of the river.

In Erythrea, cotton cultivation is carried on under the auspices of the "Società per la Coltivazione del Cotone nell' Eritrea," which has, so far, chiefly confined its activities to the Carcabat district. The Carcabat river, which waters

this district, also has periodic floods, and dams have already been constructed on it by the Company for the purpose of irrigation, but they have not fulfilled expectations, and have in many places given way. It is hoped that Government enterprise, aided by the experience gained by these failures, will prove more successful.

Means of transport are, in both colonies, at present quite inadequate to cope with the disposal of cotton in such quantities as it is hoped to produce. In Somaliland practically the only means of transport are camels, motor wagons in certain parts of the country, and during a few months of the year an irregular service of small British and Italian steamers on the Juba. Railways to serve the cotton regions and leading to the port of Brava (itself not yet constructed) are urgently needed. In Erythrea the Government has already some roads under construction or in project, but there is need for more.

The labour problem is the most serious of all. In both countries the natives are accustomed to pastoral rather than to agricultural pursuits, and the introduction of labour from other countries is considered imperative. Arabs, Sudanese, and natives of the Lake Chad and Upper Niger districts have been employed in Erythrea, the first-named giving the most promising results; and for the solution of the problem in Somaliland Dr. Scassellati-Sforzolini suggests the importation of labour from China, India, Arabia, or Abyssinia, as well as the adoption of machinery such as has been tried in the United States of America. It is suggested that until the Government has satisfactorily solved these problems, private enterprise is offered little prospect of success.

A Disease of the Oil Palm in the Belgian Congo.—Up to the present time comparatively little information has been published as to fungoid diseases which attack the oil palm, and in view of the vast importance of the subject it has been thought desirable to call attention to a disease which has been recently brought to the notice of the Imperial Institute.

According to a report furnished to the Imperial Institute a fungus has been found attacking the oil palm in the Belgian Congo. It is stated to be very common and widely distributed, attacking mature trees as a rule, but sometimes killing young ones. In large trees the fungus may be present for a considerable period before the tree dies, after which it persists for an indefinite period as a saprophyte, continuing to produce its bracket-shaped fructifications vigorously. Nothing resembling a true rhizomorph was found, but it was noticed that the mycelium of the fungus persists after the roots of the palm have become disintegrated, and as the roots of neighbouring palms often

intermingle it is possible that these mycelial strands may infect other trees. The fungus may also obtain entry into living trees through wounds, produced when the dead leaf-bases are cut off, by means of its spores.

A specimen of the fructification of the fungus was received at the Imperial Institute, and this has been identified at the Royal Botanic Gardens, Kew, as probably that of *Ganoderma tumidum*, Bres., a species of the Polyporeæ closely allied to *G. lucidum*, Karst.

G. tumidum is somewhat closely related to *Fomes semitostus*, the fungus which attacks the Para rubber tree, and it seems probable that the remedial measures adopted against the latter disease might also be suitable in the case of this oil palm disease. These measures consist in uprooting and burning all diseased trees, isolating the infected area by means of a trench 2 ft. deep, and treating the soil in the neighbourhood with freshly slaked lime.

Mineral Production of New South Wales.—The *Ann. Rep. Dept. Mines, New South Wales*, 1914, gives £10,499,720 as the value of the total mineral output during 1914. This is a decrease of £1,595,364 on the value of the output for the previous year. The decrease is attributed to the disabilities under which the mining industry has laboured since the outbreak of the war, though under the circumstances the output must be considered very satisfactory, since it has only been exceeded on three occasions, viz. in 1907, 1912, and 1913.

The chief items of the output, with values in 1913 and 1914, are given in the following table:

	1913. £	1914. £
Coal	3,770,375	3,737,761
Silver-lead	3,563,804	2,934,065
Zinc	1,547,987	1,020,711
Gold	635,703	528,873
Portland cement	402,249	415,000
Copper	598,733	274,671
Silver	244,321	307,198
Tin	421,292	267,130
Lead	365,742	370,106
Iron	186,252	254,257

The large decrease in the output of silver-lead-zinc ore is a notable feature, and showed on the total a decrease of £1,089,774 compared with the previous year. This was due largely to a curtailment of operations at the Broken Hill and other mines due to the outbreak of the war. This curtailment is sufficiently explained by the fact that 50 per cent. of the lead concentrates produced at Broken Hill was sent to Belgium, Germany, France, and Austria, and was handled almost entirely by German firms. The position as regards zinc smelting was still more serious, as only 2·5 per cent. of the total zinc concentrates produced was

smelted in Australia, the remainder being sent mainly to Germany and Belgium to be smelted. Before the war broke out 8,814 men were employed at the Broken Hill mines. On September 17, 1914, only 655 of these were working full time, whilst 3,798 were on half time, and 4,361 were unemployed.

The decrease in copper production was in part due to the war, but in part also due to the closing down of the smelters at Great Cobar in April 1914.

The tin output was also adversely affected.

Of the less important items of the mineral output there were increases in the production of alunite, antimony, bismuth, limestone, molybdenite, oil-shale, scheelite, and wolframite; and decreases in diamonds, opal, and platinum.

A notable feature was the revival of quicksilver mining at the Ewengar Cinnabar Mine in the Drake Division. The ore from this mine is carted a distance of 23 miles to Pulganbar, where the reduction plant is situated, and treated there along with Pulganbar ore.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.*

AGRICULTURE

MANURES

Considerable quantities of waste products have recently become available at the Yorkshire cloth mills as a result of the present large production of cloth for military purposes. Some of these waste products contain wool and for this reason are stated to possess considerable manurial value, as wool contains about 17 per cent. of nitrogen and has long been known to be a good manure (*Journ. Bd. Agric.* 1915, **21**, 1087). The material available is in the form of short threads obtained in the working up of wool and woollen cloths and is usually known as shoddy. The manurial value of the shoddy depends on the proportion of wool it contains, and purchases should only be made on the basis of the nitrogen content. Several grades exist; those that are practically pure wool and contain 10 to 15 per cent. of nitrogen; those admixed with more or less cotton and that contain 5 to 10 per cent. of nitrogen; and those which are practically all cotton and dirt and contain only

2 to 5 per cent. of nitrogen. The first and second grades are largely used by fruit and hop growers. It is stated that shoddy is one of the cheapest nitrogenous manures on the market and can normally be obtained at about four to five shillings per unit of nitrogen at the Yorkshire mills. Carriage is rather heavy on such bulky material, so that on farms in the south the total cost may be seven to eight shillings per unit. Even at this price, however, shoddy is said to be distinctly a useful manure, although it is doubtful whether the lowest-grade shoddies, containing less than 5 per cent. of nitrogen, can be used advantageously at any distance from the mill.

Bulletin No. 49, *U.S. Dept. Agric.* (1914) deals with "the use of radioactive substances as fertilisers." It is stated that the so-called "radioactive manures" consist of the residual ores from which uranium has been removed or of uranium-radium ores which are too poor to be used for the extraction of radium. It is shown that the average quantity of radium present in the soil available in the top 12 in. of an acre of land is about one hundred times greater than is contained in the quantity of radioactive manure commonly recommended for application to such an area. In botanical research and possibly in greenhouse practice, where the results obtained may justify the expense involved, it is thought that the radio-elements may prove of some value; but when the scarcity of these elements is taken into account, it does not appear that they can have any practical application as a manure for general farming. Evidence is given to show that the action of these ores and residues on plants is due to the chemical properties of the uranium rather than to radioactivity, and that the conflicting results obtained with radioactive manures from different sources are to be explained largely by the presence or absence of uranium and of such non-radioactive elements as soluble salts and acids.

Foodstuffs and Fodders

Maize.—A large increase in the production of maize in Southern Rhodesia is expected during the current year. The area planted is 188,453 acres and the estimated yield is 1,006,624 bags of 203 lb. The estimated surplus of maize available for export is 510,000 bags. The exports of maize from Southern Rhodesia during the year 1914 were 41,027,448 lb., value £111,984, as compared with 7,823,100 lb., value £24,074, in the previous year.

Sorghum.—In No. 1 of a series of publications on Egyptian agricultural products, issued by the Ministry of Agriculture, Egypt, Mr. G. C. Dudgeon, F.E.S., Consulting Agriculturist to the Ministry of Agriculture, Egypt, deals with *Sorghum vulgare*, Pers. (*Andropogon Sorghum*, Brot.), the Great

Millet (Durra Baladi or Durra Rafia in Egypt), and *Sorghum Halepense*, Pers. (Garawao). The monograph contains a botanical description of *S. vulgare* and its Egyptian varieties, and a full account of the methods of cultivation of the ghedi (summer) and nabari (autumn) varieties, including the preparation of the land, sowing, manuring, thinning and transplanting, irrigation, harvesting, and yield. Insect pests and fungoid diseases are dealt with, and the uses of the grain, for local bread making and for the preparation of a malted liquor, are described.

Sudan Grass as a Forage Crop.—*Farmers' Bulletin* No. 605, 1914, of the *U.S. Dept. Agric.* states that, as a result of a search for forms of wild Andropogons which do not have rootstocks, a new hay grass, "Sudan grass," was obtained in 1909 from the Director of Agriculture and Lands of the Sudan. Under cultivation in the United States the grass has shown itself to be an annual. It is very closely related to the cultivated sorghums, and hybridises with them readily. In appearance it is similar to Johnson grass, but is somewhat more erect, taller, and has a broader leaf. It lacks entirely the underground rootstocks which make Johnson grass a pest. Sudan grass, when sown broadcast or in drills, averages about 3 to 5 ft. in height and has stems about $\frac{3}{16}$in. in diameter. If grown in rows and cultivated it reaches a height of 6 to 9 ft. and the stems are about $\frac{1}{4}$in. thick. When given plenty of room it stools very freely. This tendency is most apparent after the first cutting and makes the hay from the second cutting usually of finer texture than that from the first.

Sudan grass, like other sorghums, does best in a warm climate. In favourable seasons, where the growing period is long, as many as four cuttings can be obtained in one year. It does best on a rich loam, but it has been grown successfully on almost every class of soil from a heavy clay to a light sand. The surface should be made rather firm before the seed is sown, and it is best to sow after the soil has become warm. The grass is usually harvested with a mower. It cures readily, the leaves are retained well, and if it has been cut at the right stage of maturity and handled properly, it is stated to make a bright, leafy, sweet hay of the best quality. The seeding habit of the grass is good, and large returns are being secured from the seed produced.

According to the *Rep. Hawaii Agric. Expert. Sta.*, 1914, p. 38, Sudan grass planted in 1913 did well and yielded at the rate of 31 tons of green forage per acre at the first cutting, and at the rate of 30 tons at the second cutting ($5\frac{1}{2}$ months after sowing). The grass grows rapidly and produces a heavy yield wherever it has been tried in Hawaii except at high elevations,

The *Rhodesia Agric. Journ.* (1915, **12**, 212) states that Sudan grass has been introduced by the Division of Botany in Rhodesia, where its value, in addition to being a summer hay crop, lies in the fact that it makes quicker growth as a winter fodder under irrigation than oats, barley, or wheat. After a cutting had been taken in June 1914, the plant attained its full height of about 6 ft. in eight weeks' time.

According to the *Agric. Gaz. New South Wales* (1915, **26**, 395), Sudan grass was first grown in New South Wales by the Department of Agriculture in the summer of 1913-14. It was observed that the seed germinated readily and growth was rapid. Under warm and fairly moist conditions heading occurs about three months after sowing. At least two cuttings can be obtained during the season.

Judging from the results recorded above, Sudan grass would appear to be worthy of attention with a view to introduction as a forage crop in many parts of the British Empire where the climate is suitable and where such a crop is required.

Oils and Oil Seeds

Aleurites triloba.—As a result of the Hawaii Experiment Station having called attention to the well-known oil seeds yielded by this species, an active demand for the oil appears to have arisen, and many paint and varnish manufacturers in the United States have expressed a desire to use the oil (*Rep., Hawaii Agric. Sta.*, 1914, p. 19). A small plant has been erected in Hawaii for oil manufacture, and it has been found that 1 ton of nuts yields 40 gallons of oil; a company is being organised to manufacture the oil, and one firm is considering the possibility of buying up the whole available supply of nuts. It is hoped that the oil will be expressed in Honolulu, as the residual cake would have a good local value as a manure.

Coconuts.—Although the export of copra from the Philippine Islands in 1914 was 5,000 tons greater than in 1913, the amount of copra exported was 55,000 tons less than in 1912; the decreased export is said to be in part due to local oil production, which accounts for 20,000 tons of copra (*Bd. of Trade Journ.*, 1915, **89**, 149).

Oil Palm.—Plots of plants of different varieties of oil palms have been planted in the Southern Provinces, Nigeria (*Rep. Agric. Dept., S. Nigeria*, 1913, p. 6), in order to ascertain whether they will grow true to seed.

Miscellaneous.—According to the *Rhodesia Agric. Journ.* (1915, **12**, 138) the British South Africa Company's oil-mill at Salisbury was to be ready to receive consignments of oil

seeds in May. The following prices were to be paid for seeds delivered at the factory; ground nuts, *7s. 2d.* per bag of 83 lb., shell not to exceed 30 per cent.; castor seed, *1d.* per lb.; sunflower seed, *¾d.* per lb.; linseed, *2d.* per lb.; cotton seed, *¾d.* per lb. The prices are subject to market fluctuations; the Rhodesian Railways have agreed to give special freight facilities.

For the hydrogenation of oil (cf. this BULLETIN, 1913, **11**, 660, and 1915, **13**, 181) the use of catalytic metals such as nickel and cobalt in the form of thin films has been patented by Baskerville and Hagemann (Pat. No. 3344 of 1914). It is claimed that the chief advantages of the use of thin films is that they remain suspended in the oil during reaction and can also be removed subsequently with ease and revivified.

Owing to the war, conditions have been favourable for the Japanese oil millers, who have been enabled to extend their business in Europe and also in Australia, the Dutch Indies, and America (*Trop. Life*, 1915, **11**, 64). Rape seed, grown in Japan, is worked principally in Kyushu, seed oil in Nagoya and the neighbourhood, and soy beans from China and Manchuria in Kobe and Yokohama. American machinery is being used largely, and it is suggested that British manufacturers should attempt to obtain a share in the trade in oil machinery.

Seeds of *Schleichera trijuga* from the Central Provinces, India, yielded 62 per cent. of kernels, containing 65·9 per cent. of oil; a yield of 57·5 per cent. of oil was obtained by hot-pressing the seeds in a hydraulic press, equivalent to 35·9 per cent. on the whole seeds (*Rept. Bd. of Scientific Advice for India*, 1913-14, p. 19).

RUBBER

Hevea.—In *Bulletin* No. 16, 1915, *Dept. Agric., Ceylon*, Campbell records the results of investigations on tapping and the storage of plant food in *Hevea brasiliensis*. The results show that in the case of normal, careful tapping starch disappears from the wood directly behind the tapping cut and partially from narrow areas of bark below and on each side of the tapped surface. In most of the experiments these areas did not exceed 1½ in. in breadth, and were generally much less. The starch content of bark was usually normal down to the top of the tapped area. With the exception of slight and localised withdrawal of starch in the immediate neighbourhood of the tapping cut, the food supply did not disappear from below the tapped area. It is evident, therefore, that the effect of tapping is purely local, and justifies the assumption that change of tapping area from one part of the tree to another should be as effective as resting the tree entirely.

The results are widely different from those of Fittig, and the author is of the opinion that Fittig's results were due to drastic tapping, or to the fact that the trees were experimented with during the winter season.

In *Bulletin* No. 13 (1914), *Dept. Agric., Ceylon*, Petch records the results obtained by tapping one of the larger old Hevea trees at Henaratgoda. This tree is one of the largest in Ceylon, its girth in 1914 being 117 in. at 3 ft. from the ground. In all probability the seedling was sent from Kew in 1876 and was planted in 1877. Tapping was commenced in December 1908, and continued more or less intermittently, different systems of tapping being employed until August 1913, a total weight of 392 lb. of rubber being obtained.

Tapping experiments with Hevea trees at Agege, Southern Provinces, Nigeria (*Rep., Agric. Dept., Southern Nigeria*, 1913, p. 10), show that satisfactory yields may be expected from mature trees. Four trees, twenty-one years old, were tapped 117 times, and yielded nearly 34 lb. of rubber.

According to Kerbosch (*Teysmannia*, 1915, **26**, 43) the superiority of rubber prepared by the Brazilian method over plantation rubber prepared by coagulation, followed by smoking, is due to the effect of the evaporation of the latex in the former process. The author quotes the results of experiments on the relative oxidisability of rubber prepared by different methods, showing that rubber prepared by coagulation oxidises more easily than rubber prepared by the evaporation of latex and that smoking does not have an appreciable effect on oxidisability. Unfortunately, the experiments appear to have been carried out on far too small a scale to be of practical value, especially in view of the fact that little or nothing is known as to the connection between quality and oxidisability.

Gorter (*Teysmannia*, 1915, **26**, 82) records the results of viscosity experiments on rubber prepared from trees planted in 1882 and 1908, the viscosity figures being 1·5 and 1·0 respectively. No important conclusions are drawn, but the author suggests that valuable results may be reached by further investigation.

An apparently new, and at present unnamed, root disease of Hevea has been found on trees in the Government plantation at Calabar (*Rep., Agric. Dept., Southern Provinces, Nigeria*, 1913, p. 41).

About 25 per cent. of the trees originally planted at Agege were in 1912 found to have died, chiefly owing to fungoid pests which appear to have been encouraged by the fact that the plantation was not stumped until 1912; the chief pests are *Polyporus lignosus*, Kl., and *Hymenochæte noxia*, Berk.; the former appears to be very common and stumps of some fifteen species of bush trees, as well

as various economic plants, are known to harbour the disease.

Manihot Species.—According to Anderson different trees of *Manihot Glaziovii* show wide variations in yield of rubber (*Rep., Hawaii Agric. Expt. Station*, 1914, p. 51). As the plant can be propagated by cuttings it should therefore be possible to select trees known to give high yields and probably obtain extensive plantations of trees giving improved yields of rubber. Experiments have already indicated that trees grown from selected cuttings give more uniform yields of rubber than those in ordinary plantations, while two-year-old trees from selected cuttings gave yields of rubber equal to those from six-year-old trees in ordinary plantations. It will be some years before it can be definitely shown that much improvement in yield can be ensured by this method. Manurial experiments with Ceara trees showed in all cases an increase in the yield of rubber from trees on manured plots over those on untreated plots (*loc. cit.* p. 55). The increase varied from 3 per cent. in the case of nitrate alone to 19 per cent. when a mixture of superphosphate and potassium sulphate was employed. Roselle (*Hibiscus sabdariffa*) has given good yields of fruit as a catch-crop in Hawaii (*loc. cit.* p. 52), and although there is practically no market for the fresh fruit, farmers and planters are taking up its cultivation apparently with the idea of canning or preserving the fruit. Artificial drying of the fruit was found to be necessary. In the Nahiku district, where the plants grow to a large size, a spacing of 5 by 5 ft. was found to be rather close. On the lower elevations the plants grew to a height of 8 to 10 ft., which rendered picking of the fruit difficult, although they yielded at the rate of 10 lb. of fruit per tree, or about 15,000 lb. of fruit per acre. It is concluded that roselle will be a suitable crop to grow in Ceara plantations. Damage was at first caused by cut-worms, but was avoided in later plantations by cutting ditches round the nurseries, planting between the seasons when cut-worms are prevalent, and by keeping the young plants in the nursery until 1½ to 2 ft. high.

Miscellaneous.—Two new instruments, the Shore elastometer and durometer, have been devised for testing respectively the elasticity and hardness of rubber goods (*India Rubber World*, 1915, **52**, 430). The instruments depend for their action upon the resistance of the sample to penetration by needle points of standard size.

A chart has been published by the uniformity committee of the Rubber Growers' Association giving recommendations for the treatment of Hevea latex and the preparation and curing of the rubber (*India Rubber World*, 1915, **52**, 374). It gives in a concise form a large amount of useful information.

Fibres

Cotton

India.—The improvement of cotton in Berar is the subject of a paper by D. Clouston, M.A., B.Sc., Deputy Director of Agriculture, Central Provinces, in the *Agric. Journ. India* (1915, **10**, 148). An experiment farm was established at Akola in 1907. The cotton grown at that time was known as "katilvilayti" or "jari" and consisted of six distinct varieties of *Gossypium neglectum*. These varieties have been separated and selected, and it has been demonstrated that *G. neglectum* var. *roseum* is by far the most profitable cotton to cultivate under the conditions of soil and climate existing in the Central Provinces. This is a white-flowered variety which gives a ginning yield of 40 per cent. Considerable attention has been devoted to it, and plant-to-plant selection has been practised. Of the many strains raised from single mother plants, the highest yields were given by one which has been termed "No. 1 roseum." The seed of this strain has been distributed to growers year by year in increasing quantities until this year the quantity amounted to about 2,000,000 lb., the production and distribution being effected by private seed-farms under the supervision of the Department of Agriculture. The rapid increase in the number of these farms, however, rendered more efficient supervision necessary, and some of them have therefore been converted into the central farms of co-operative agricultural seed unions. Each union consists of ten or more members who guarantee to grow only selected "roseum" and keep all the seed for distribution. From one to ten villages may be included in a union. The central farm of the union supplies pure seed to the branch farms and a union inspector (or "kamdar") is appointed to ensure that the seed of the branch farms is kept pure. The inspector supervises the sowing, uproots any alien plants that appear, and controls the ginning of the seed-cotton, and the bagging, labelling, and distribution of the seed. Twenty-two unions have now been started, and this system of organisation renders it possible to introduce improvements on a large scale with a minimum amount of effort.

An account of the efforts made in the last decade to improve the cotton of the Tinnevelly area has been given by H. C. Sampson, B.Sc., Deputy Director of Agriculture, Southern Division, Trichinopoly, in the *Agric. Journ. India* (1915, **10**, 137). The crop is composed of two varieties, known as "uppam" and "karunganni." The first attempts to improve the cotton were by securing and distributing seed of each variety as free from admixture as possible. Subsequently plant selection was practised with each

variety, but as it was found impossible to prevent them from crossing, the selection of "uppam" was discontinued. The "karunganni" crop grown at the Koilpatti Agricultural Station was found to be so superior to that being distributed by the Agricultural Department that it was decided to start seed farms where the seed from the Koilpatti Station could be grown and the system of drill cultivation demonstrated. More recently village seed depots have been established on the understanding that the villagers would co-operate for the joint sale of the seed-cotton in order to get back their own seed from the ginning factories. During last season, twenty villages co-operated in this way and sufficient seed has been stored in the depots to sow about 12,000 acres next season. Seed of a unit strain will be sold to these villages in the coming season on the same conditions as before. This strain is a great improvement on the cotton now being grown: it has been found to give a yield of 620 lb. of seed-cotton per acre as against an average yield of 454 lb. for ordinary selected "karunganni" and a ginning percentage of 31·3 as compared with the district average of 25; spinning trials have shown that this cotton is quite suitable for 40's yarn as against 26's for the ordinary selected "karunganni."

West Indies.—An account of two physiological affections of cotton, termed "curly-leaf" and "loggerhead," has been given in the *West Indian Bulletin* (1914, **14**, 304). Both these diseases have occurred in St. Kitts and Nevis. They may appear at any stage of the active growth of the plants, and their actual nature is not known, but they are probably associated with enzyme disturbances. Sometimes they occur separately and sometimes both are present in the same field. The curly-leaf affection is characterised by an abnormal growth of the stem, branches, and leaf-stalks, thus rendering the plant tall and lanky, and by the margins of the leaves presenting a strongly crimped appearance. The disease renders the flower-buds liable to turn black and drop off at an early stage in their development and causes a great reduction in the yield of cotton from fields in which it is prevalent. In the case of the loggerhead disease, there is a suppression of growth of the stems and branches and the plant becomes dwarfed; in this respect the loggerhead affection is the exact opposite of the curly-leaf form. The leaves are not crimped at the edges, but there is often a puckering of the tissue along the main veins owing to their insufficient elongation. The flowers turn black and fall from the plant just as in the case of the curly-leaf disease. The latter affection seems to be connected with rapid growth due to an excess of water, the prevalence of cloudy weather, or the shading of the plants, and it disappears when these conditions are changed. The loggerhead

disease is erratic in its occurrence, and its dependence on the weather is not so clear; in some places it seems to appear only when abnormal weather is experienced or if planting has been carried out at an unsuitable time. The diseases have not caused severe damage except in a few cases, and there is no reason for anticipating any serious increase in their occurrence. It is not considered that any remedial measures are possible, but it is thought that the diseases can be avoided to a large extent if planting is carried out with due regard to the expectation of rain and if the plants are not crowded.

United States.—On account of the unsatisfactory economic conditions of the Sea Island cotton industry of the United States in 1912–13, a special investigation was undertaken by the Department of Agriculture at the request of the farmers of South Carolina. The investigation embraced the whole of the Sea Island districts, and the results have been published as *Bulletin* No. 146 (1914), *U.S. Dept. Agric.* The Sea Island cotton crop of 1912–13 was only 73,777 bales as against 122,744 in 1911–12, lower prices were obtained, the exports were 20 per cent. less, the American consumption decreased by nearly 60 per cent., and the stock at the end of the season was the highest on record, amounting to 15,639 bales. This situation was due to several causes, among which may be mentioned the competition of Egyptian cotton, the deterioration in quality of the Sea Island crop, changes in the tariff, changes in the style of women's clothing, and changes in the fine goods trade. Many spinners substituted Egyptian Sakellaridis cotton for Sea Island and stated that their reasons for doing so were that the former gives less waste in the processes of manufacture, that it works better in the carding room, that it makes stronger yarn and stronger cloth, and that it is paid for ten days after receipt, whereas Sea Island has to be paid for about thirty days before it reaches the New England mills. Owing partly to the competition of West Indian Sea Island cotton, many of the farmers in the Sea Island districts planted Upland kinds, sometimes in fields immediately adjoining Sea Island plantations and sometimes even in the same field, and consequently a general deterioration in the quality was brought about by hybridisation.

The farmers in South Carolina are in most cases considerably in debt to the factors who advance the money and supplies required for producing the crop and sell the produce on commission. Moreover, there are other conditions and practices existing which are detrimental to the trade and are difficult to change or eradicate. The cost of cultivation is much higher than it ought to be owing to the use of the hoe instead of machine ploughs. The prospects of the Sea Island crop are rendered even more uncertain

by the approach of the boll weevil, which at its present rate of progress will overrun the entire Sea Island area in a few years. The farmers are therefore advised to consider the substitution of other crops, especially foodstuffs, for cotton.

In Georgia and Florida somewhat better conditions prevail, but Upland cotton is largely replacing Sea Island. The reasons given for the preference for Upland cotton are that it gives a larger yield, is less easily ruined by storms, is easier to pick and gin, is less exhausting to the land, always finds a ready market, and, on the whole, is just about as profitable as Sea Island. Most of the cultivation is done with ploughs or cultivators.

In conclusion it is pointed out that it is certainly desirable that Sea Island cotton should continue to be grown, but only if the crop can be made profitable. It is also desirable that the spinner should have a double source of supply of the raw material, and not be entirely dependent on Egypt for all cottons of extra long staple. It is therefore suggested that the planters and spinners should co-operate to their mutual benefit.

An account of a new system of cotton cultivation is given in a *Bulletin*, entitled "Single-stalk Cotton Culture," issued by the Bureau of Plant Industry, U.S. Dept. Agric. The aim of this system is to produce plants with a single erect stalk bearing numerous, well-developed fruiting branches but no vegetative branches or secondary stalks. By the old system of cultivation bushy plants were produced with numerous leafy branches which often filled the space between the rows and smothered the lower fruiting branches. The new system produces narrow, erect plants with only the horizontal fruiting branches projecting and leaves an open space between the rows, and the lower fruiting branches which produce the early bolls are therefore able to develop much more satisfactorily. The suppression of the vegetative branches is effected by leaving the young plants close together in the rows. Thinning is not done until the plants are from 6 to 12 in. high instead of when they are from 2 to 4 in. high. If the young plants are not more than 6 in. apart, most of them do not produce vegetative branches, but only an upright, central stalk and horizontal fruiting branches. The final distance to be left between the plants and between the rows depends on the luxuriance of growth and the local conditions. With plants only 3 or 4 in. apart in the rows there may be less injurious crowding than with large, branched, bushy plants, 3 ft. apart. The rows may be separated from one another by as little as 3 ft., but this causes increased risk of damage by early drought. The single-stalk method facilitates the cultivating and harvesting of the crop. Other advantages are that the close proximity

of the plants in the rows affords them mutual protection, and that the plants are less liable to suffer from drought. The system also facilitates control of the boll-weevil. As the plants stand up well from the ground and vegetative branches are absent, the sun is able to reach the fallen squares containing the weevil larvæ, and the fallen squares can be more easily collected by hand. The new system also results in an earlier production of flowers and bolls and considerably increased yields of cotton.

Attention has been devoted recently to the control of cotton wilt and root-knot, which occur in the Southern States to a serious extent, especially on sandy soils, and cause considerable loss to the farmers. An account of these diseases and the best methods for their eradication has been given in *Farmers' Bulletin*, No. 625 (1914), *U.S. Dept. Agric.* Wilt causes the death of large numbers of plants, stunts many others, and thus reduces the yield. Root-knot also effects a reduction in the yield by causing the plants to be dwarfed. When the two diseases occur together, as frequently happens, the cultivation sometimes results in an actual loss. Wilt is caused by a fungus, *Fusarium vasinfectum*, Atk., which enters the roots from the soil and grows vigorously in the vessels of the roots and stems, thus interrupting partially or entirely the supply of water to the plant. It is most severe in wet seasons. The disease cannot be completely eradicated by crop rotation, although rotations of seven to ten years have been found to reduce it to some extent, but the only successful method of control is by means of wilt-resistant varieties of cotton. Such varieties have been produced and have been improved by selection for greater resistance, larger yield, longer fibre, and higher ginning percentage. Among the more promising of these varieties are "Dillon," "Dixie," and "Modella." In order to maintain the resistance to wilt, careful attention must be given to breeding. Care must be taken to prevent deterioration of the plants by hybridisation with non-resistant forms growing in adjacent fields, through lack of selection or by mixing of seed in the ginning factories. Root-knot is caused by minute eel-worms or nematodes which bore into the roots and set up an irritation resulting in the formation of irregular swellings or galls on the roots. The disease can be controlled by means of rotation, as several important crops, such as cereals and grasses and certain races of cow-peas, are entirely immune. In order to meet the demand for wilt-resistant cotton seed, arrangements have been made with some of the farmers in South Carolina and Georgia to grow seed for sale under the supervision of the Department of Agriculture. Efforts are also being made to disseminate information about wilt and root-knot as widely as possible.

TOBACCO

According to the *Rhodesia Agric. Journ.* (1915, **12**, 309) there has been an enormous falling off in the acreage planted with tobacco in Southern Rhodesia during the current season, the total area cultivated by European farmers being 1,556 acres, and the estimated yield 643,775 lb. This decrease is attributed to the fact that most of the tobacco planters have reverted to maize growing, for this season at least. In the Marandellas district of Mashonaland for example, which is one of the chief tobacco-growing regions, the decrease in the area under tobacco is almost exactly counterbalanced by the increased acreage under maize.

An account of the tobacco-growing industry in Italy and of the varieties cultivated is given in the *Monthly Bulletin of Agricultural Intelligence and Plant Diseases* (1915, **6**, 371). The total area under tobacco grown for the Tobacco Monopoly amounted to 12,372 acres in 1901, rose to 18,942 acres in 1910, but fell in 1912 to 16,965 acres. The area under tobacco grown for export has diminished from 3,745 acres in 1909 to 705 acres in 1912. The yearly output of the country (about 20,000,000 lb.) is barely one quarter of the quantity that is bought each year by the Monopoly, and it is thought that the local production might be increased to advantage. The conditions of climate and soil in Italy are almost everywhere favourable to the crop, the yield per acre is often higher than that obtained elsewhere, and the quality of the product on the whole is good.

About twenty varieties are cultivated, of which one-half are Italian strains and the remainder American and Levantine varieties. The tobacco produced by the Italian strains on the whole is unsuitable for the manufacture of cigars, cigarettes, or pipe tobaccos, and is more adapted for the manufacture of snuff, but the best smoking tobaccos, such as Nostrano, Secco, and Brasile Beneventano are being grown to a greater extent each year. Of American tobaccos the most important variety is Kentucky, of which about 11,000,000 lb. are produced annually; it is grown all over the peninsula, and that produced in the Roman Compagna, Tuscany, Abruzzi, Calabria, and the district about Salerno bears comparison, as regards strength and flavour, with that of the United States. Less important from the point of view of quantity grown are Virginia and Burley, but these have also given good results in several districts. Some of the Levantine tobaccos, especially Xanti Yaka, grown in the provinces of Lecce and of the Abruzzi, have a good aroma and are of delicate texture and can stand the competition of Macedonian tobaccos even on foreign markets.

FORESTRY AND FOREST PRODUCTS

Eastern Hemlock.—The eastern hemlock (*Tsuga canadensis*, Linn.) occurs in the white pine region of eastern North America and extends from Nova Scotia to east central Minnesota in the west, and to northern Georgia and Alabama in the south. Though excelled in most respects by other trees in the region of its growth, it is none the less a most important member of the remaining old-growth forests. Its lumber serves many purposes for which pine was formerly demanded; its wood supplies more raw material for paper pulp than does any other in the United States except spruce, while the amount of its bark used in the United States for tanning exceeds that of all other native species combined. It is, however, a slow-growing tree and it will not pay to encourage its reproduction on fertile soil where a good deal of the remaining old-growth hemlock timber at present exists and which is suitable either for agriculture or for raising timber crops of rapidly growing species. In *Bulletin* No. 152, 1915, *U.S. Dept. Agric.*, a full account of the characteristics and distribution of the tree is given, together with information as to the amount and value of the standing timber in the United States, its utilisation for lumber, pulp, tanning bark, and other purposes, forest management, etc.

Forest Planting in the Eastern United States.—*Bulletin* No. 153, 1915, *U.S. Dept. Agric.* contains valuable information as to the establishment and care of timber plantations on farms. Although specially adapted to the conditions obtaining in parts of the Eastern United States, it should prove of value to farmers in other regions, part of whose land can be more profitably planted with timber than with an agricultural crop. Among the trees dealt with are cottonwood (*Populus deltoides*, Marsh.), silver maple (*Acer saccharinum*, Linn.), larch (*Larix europæa*, DC.), Scots pine (*Pinus sylvestris*, Linn.), white pine (*P. strobus*, Linn.), Norway spruce (*Picea excelsa*, Link), black walnut (*Juglans nigra*, Linn.), and ash (*Fraxinus lanceolata*, Borkh., and *F. americana*, Linn.). Particulars are given in each case as to the yield and value in actual practice, and a useful table gives the species suitable for different soils in various regions, the spacing, planting method, products obtainable, and the age at which the trees reach maturity.

Germination of Teak Seed.—In the *Indian Forester* (1915, **41**, 147) an experiment is described in which the germination of teak seeds soaked in cowdung for fifteen days, and of charred seeds collected from a burnt teak forest, was compared with that of normal seeds. The seeds were sown in prepared beds early in March, and within a fortnight the charred seeds were germinating profusely and by the end

of June had produced strong plants 1½ ft. in height. The seeds soaked in cowdung began to show signs of germination at the end of April, but the plants were only 6 in. in height at the end of June. The ordinary seeds did not germinate until the beginning of June, and then only sparingly, so that very few vigorous plants were available for planting purposes in July. As a result of this experiment it is suggested that instead of regenerating an area by means of seedlings in the usual way, which often necessitates their transport for long distances, resulting in a large percentage of failures, charred seeds should be sown in May or the beginning of June on raised beds scattered over the burnt area to be regenerated. In July the seedlings can be removed from the beds and transplanted as desired over the area.

Timbers

Timber in British North Borneo.—Reference has been made previously in this BULLETIN (1912, **10**, 504) to the fact that immense forests occur in British North Borneo and that a considerable export trade in timber exists. The Government is now taking steps for a general survey of the timber possibilities of the country and has recently engaged a forestry expert to estimate the amount available, and to ascertain the kinds suitable for export (*Journ. Roy. Soc. Arts*, 1915, **63**, 765).

The entire coastline is occupied with an unbroken jungle of "nipa" palms and mangroves, but the higher ground is particularly rich in hardwoods. Of these the most valuable is "billian" or ironwood, which is extremely hard, sand-coloured when newly cut, but darkening with age. As in the case of many of the best-known Borneo woods, about 2 in. of the outside of the tree is soft and worthless, but the inside is strong, solid, and durable. The wood is ant-proof and consequently in request for building purposes in the tropics, and is also admirably adapted for cabinet work, dancing floors, interior of railway carriages, vehicles, etc. It takes a fine polish, and its only drawback is its great weight, but this is counterbalanced by its strength. The tree is comparatively plentiful all over the country, but the supply immediately round Sandakan is getting short, as many shiploads go to China each year.

"Russak" or "selangan batu" is another valuable hardwood, similar in many respects to "billian," but not so heavy, nor does it take such a good polish. It is used for general building purposes, but is preferred for posts and piles for wharves, beams for houses, and all kinds of heavy framework. The supply is almost unlimited.

Another common timber is "sirayeh," or redwood, a comparatively soft wood, very similar to Californian redwood. It is in great demand for building purposes which

do not require hardwood and has been used for the construction of railway carriages, for which purpose several shiploads have been sent to Australia.

"Urat mata" is a dark red wood with a grain not unlike that of American mahogany. It is very durable, impervious to ants and other insects, and is in much demand for ship-building, masts, and planks.

"Greeting" is a wood closely resembling Indian ebony, but the black inside sometimes has streaks of brown or red. It grows near the shore and on the edges of swamps and is very durable both in and out of water. The wood is a good imitation of English black oak, and may be used for decorative purposes, though it is almost as heavy as "billian."

A wood similar in texture and grain to "greeting" is "rungas," which is dark red with a black stain. Two or three inches of the outside are soft and worthless, but the interior has all the qualities of the most desirable hard-wood. It is durable, takes a high polish, and is not attacked by insects. It is found all over the country, but only as isolated trees.

Other valuable timbers exported are camphor wood, "mirabow," and "chindana." These all have a more or less agreeable odour, are fine grained and durable. They are in great demand in Hong Kong for the inside finish of wardrobes, chests, bureaux, etc.

Timber Industry of French Equatorial Africa.—The *Bulletin de l'Office Colonial* (1915, **8**, 1) contains a long article on the timber trade of French Equatorial Africa (Gaboon) and the effect of the European war on it. An account is first given of the various woods exported and the general condition of the timber trade in Gaboon; the timber trade and its existing situation in the principal European markets dealing in Gaboon woods is then discussed, possible new markets are suggested, and finally the future of the industry is considered.

The value of the timber exported from Gaboon has risen from £20,000 in 1898 to £332,770, representing a quantity of 150,688 metric tons, in 1913. The importance of this trade to the colony can be seen by the fact that the total value of the exports in the latter year was £1,459,520. A very large proportion (over 40 per cent.) of the timber was sent to Germany in 1913, the next most important customers being the United Kingdom (24 per cent.), France (18 per cent.), and Holland (15 per cent.).

The forests of Gaboon extend parallel to the coast from the northern boundary to the southern, a distance of over 400 miles, and inland for an average distance of 120 miles. The following are the chief timbers at present exploited:

"Okoumé" or "Angouma" is by far the most important

wood, the exports in 1913 amounting to 134,223 metric tons, valued at £254,609, of which nearly one-half went to Germany and a little more than one-fifth to the United Kingdom. It somewhat resembles mahogany, but has a larger grain, paler tint, and a lower density. It is stated to be derived from a number of different trees of which the most widely spread is *Aucoumea Klaineana*, Pierre (Nat. Ord. Burseraceæ). The wood is used in Germany for making cigar boxes and it also finds a use in cabinet work and fancy turnery. It is obtainable in logs 12 to 13 ft. long and up to 2 ft. in diameter in the rough, or 1 ft. 8 in. squared.

West African mahogany (native names "zaminguila" and "ombega"). This is furnished by several species of *Khaya* (Nat. Ord. Meliaceæ). It is lighter than the mahoganies from other parts of West Africa and of paler colour than American mahogany. It can be used for most of the purposes to which true mahogany is put and is obtainable in logs 12 to 20 ft. long and 2 to 3 ft. square.

"Douka" mahogany. This is chiefly furnished by *Mimusops Djave*, (Laness.) Engl. (Nat. Ord. Sapotaceæ). It is a beautiful wood, harder and heavier than the preceding. It is suitable for all purposes in which wood of fine quality and great resistance is required, such as the construction of railway carriages. The wood arrives in Europe in logs 16 to over 20 ft. long and from 1½ to 3½ ft. in diameter.

The exports of these two types of mahogany in 1913 amounted to 10,081 metric tons, valued at £53,332, of which nearly one-half came to this country.

A number of woods of yellow colour, and which may be called semi-hard, occur. The chief of these are "kambala" (*Chlorophora regia*, Nat. Ord. Moraceæ), which possesses some of the characteristics of the European oak, and "mandji" or "bilinga" (*Sarcocephalus Bilinga*, A. Chev., Nat. Ord. Rubiaceæ), which is used in cabinet work and carpentry.

Several woods are exported as African walnut. They are furnished principally by *Coula edulis*, Baill. (Nat. Ord. Olacaceæ) and *Vitex* spp. (Nat. Ord. Verbenaceæ), and are used in joinery and cabinet work and arrive in Europe in logs 16 to 20 ft. long and 1 ft. 6 in. to 2 ft. 6 in. square. The exports of these woods in 1913 amounted to 1,720 metric tons, valued at £5,160.

Of less importance at present are "coral wood" (*Pterocarpus Soyauxii*, Taub., Nat. Ord. Leguminosæ) and "moabi," both hardwoods, ebony (*Diospyros flavescens*, Gürke, Nat. Ord. Ebenaceæ), "zingana" or zebra wood (*Macrolobium* sp., Nat. Ord. Leguminosæ), "bubinga" or "rosewood" (*Brachystegia* sp., Nat. Ord. Leguminosæ), and "fromager," a very soft wood used in Germany for the manufacture of

one of the multiple-ply woods which are now becoming popular for packing cases and other purposes.

ECONOMIC MINERALS

Alunite.—Two occurrences of this mineral have been described recently in the *Review of Mining Operations in South Australia*, issued under the authority of the Minister of Mines. One of these is in the immediate neighbourhood of Carrickalinga Head, about 4 miles to the north of Normanville (*loc. cit.* No. 19, 1914, p. 39). The other is near Warnertown, 8¼ miles from Port Pirie (*loc. cit.* No. 21, 1915, p. 25).

The Carrickalinga alunite occurs in a westerly-dipping series of Cambrian slates and limestones, in the form of an assemblage of veins that traverse the shattered rock-mass in all directions. The veins vary in thickness from about an inch up to 3 ft. The alunite is snow-white in appearance where it is unaltered by weathering, and is of exceptional purity. It has a microcrystalline texture and breaks with a conchoidal fracture. The freshly broken surface of the mineral is described as having the appearance of unglazed porcelain. The action of weathering causes softening and disintegration, and weathered specimens are yellowish in colour. A bulk sample of the Carrickalinga alunite was found to contain 35·81 per cent. of sulphuric anhydride, 34·9 of alumina, 10·36 of potash, and 15·99 of water.

The alunite near Warnertown occurs in a bed of shale, of which it is regarded as a replacement. At one place a bed of alunite dipping very steeply to the west was found to have a thickness of 3 to 3½ ft. The material is in part granular and chalky in appearance; and in part more compact, having the appearance of unglazed porcelain. The samples of alunite examined contained varying amounts of shale, limestone, and siliceous impurity. Two samples from the bed 3 to 3½ ft. thick were found to contain 8·75 per cent. and 6·93 per cent. of potash, the former being fairly pure, whilst the latter contained an appreciable quantity of limestone and shale.

Building Stones.—The Mines Branch of the Canadian Department of Mines has issued Vol. III of a *Report on the Building and Ornamental Stones of Canada*, by W. A. Parks (Ottawa, Government Printing Bureau, No. 279, 1914). Volume I contains two parts, the first of which gives a general introduction to the subject and the second an account of the building and ornamental stones of Ontario. Volume II deals with the stones of the Maritime Provinces. This volume deals with the stones of Quebec. As in the preceding volumes, attention is given chiefly to the economic and technical aspects of the subject, and the aim has been

to deal with geological matters only in so far as was necessary to understand the problems presented. The volume is excellently illustrated.

Coal.—The Geological Survey of India has published a well-illustrated paper by Dr. L. L. Fermor *On the Geology and Coal Resources of Korea State, Central Provinces* (*Mem. Geol. Surv. India*, 1914, **41**, 148). Korea State lies between 22°56′ and 23°48′ N., and 81°56′ and 82°47′ E.

There are numerous exposures of pre-Cambrian rocks. Lying unconformably on these are the rocks of the Gondwana formation, including the Talchir conglomerate and the Barakar series. The Gondwana beds are covered by Deccan trap. The Deccan trap runs across the State in an E.N.E. direction, in the form of an irregular strip; no part of the trap was found by Dr. Fermor to be extrusive; and he infers from his observations that it consists entirely of a huge intrusive sill.

It is in the Barakar series that the coal seams occur. The rocks of this series include micaceous sandstones, sandy shales, shales some of which are carbonaceous, and coal. The coal seams vary in thickness from 1 in. up to about 12 ft. The coal is of the typical banded Gondwana variety, consisting partly of bright, and partly of dull layers.

At one locality (Upper Dubpani) the bright layers of coal were found to contain numerous small concretions of kaolinite having the form of flattened spheres and an average diameter of about ¼ in. These concretions are surrounded by a very thin brown coat and an outer shell of black coal. Cracks radiate from the concretions in the surrounding coal through a distance of ½ in. or so. Dr. Fermor regards these concretions as giving support to the view that the bright layers of the coal have the nature of a colloidal substance that has segregated from a mixture containing earthy matter.

The chief coal-bearing areas examined by Dr. Fermor are dealt with by him under the names of the Sanhat and Kurasia coalfields. The following table shows the average composition of samples collected from these two fields, compared with the average percentage composition of samples from the Raniganj coalfield:

	Sanhat coal-field.	Kurasia coal-field.	Raniganj upper seams.	Raniganj lower seams.
Moisture	4·49	7·47	6·81	3·76
Volatile matter . . .	23·58	29·48	32·19	31·51
Fixed carbon . . .	45·21	48·40	44·76	49·68
Ash	26·72	14·65	16·24	15·05
Calorific value (calculated)	5,674[1]	6,217[1]	5,870[1]	6,417[1]

[1] *Small calories.*

From these analyses the coal of the Kurasia field is seen to be of a better quality than that of the Sanhat coalfield, and it is suggested that in the exploitation of the coals preference should be given to the Kurasia coalfield. In passing from the upper to the lower horizons, the Kurasia coals show a steady decrease from about 10 to about 5 per cent. of moisture, a variation resembling that shown by the coal at different horizons in the Raniganj coalfield.

Gold.—In the *Bulletin Amer. Inst. Min. Eng.* (1915, p. 609), J. B. Tyrrell contributes a paper on the "Gold-bearing Gravels of Beauce County, Quebec." Gold is obtained in this area from the alluvial deposits along the tributaries of the Chaudière river. The country in which the gold-bearing deposits are situated is a dissected tableland, with a mean elevation of 1,000 or 1,100 ft. above the sea, lying between two old mountain ranges—the Megantic and Sutton ranges.

These mountains are composed of pre-Cambrian gneisses, together with talc, chlorite, and mica-schists. Between the ranges and occupying the auriferous plateau area of the Chaudière river are slates, quartzites, and sandstones that are supposed to be of Cambrian age, though they resemble the slates and schists of pre-Cambrian age in northern and western Ontario. These early Palæozoic rocks have been severely crushed, and the beds are as a rule steeply inclined. They are, moreover, invaded by numerous intrusions that vary in character from quartz-porphyry to peridotite.

Mr. Tyrrell infers from his investigations that gold was probably introduced into the folded Palæozoic rocks subsequently to, but in close association with, the quartz porphyry and other acid intrusions. It was introduced along with the pyrite and other sulphides in the siliceous waters that formed the quartz veins.

Throughout the long period that followed the late Palæozoic uplift of the area, these rocks were extensively denuded and the gold was washed into the alluvial deposits, where it became concentrated in the stream-gravels. Glaciers subsequently scoured away most of the gold-bearing alluvium and left behind a mantle of boulder clay. In some localities, however, the pre-glacial auriferous gravels have been preserved, and it is chiefly from these that the gold has been obtained.

The gold obtained from the tributaries of the Chaudière river is chiefly of a coarse character. Nuggets of considerable size have been obtained from the gravels, and one of these, found on the Gilbert river, weighed 51 oz. 18 dwt. 6 grains.

Gypsum.—The Mines Branch of the Canadian Department of Mines has issued a publication on *Gypsum in Canada*,

its Occurrence, Exploitation and Technology, by L. H. Cole (Ottawa Government Printing Bureau, No. 245, 1913).

The gypsum industry is one of the most important and one of the oldest of the mining industries of Canada. In order of importance amongst the world's gypsum producers, Canada ranks third. The chief producing provinces are Nova Scotia, New Brunswick, Ontario, and Manitoba; but a small amount is also obtained in British Columbia. The output of these various provinces during 1913, according to the *Annual Report on the Mineral Production of Canada* for 1913, was as follows:

	Tons.	Value in dollars.
Nova Scotia	404,801	479,515
New Brunswick	103,954	279,395
Ontario	62,315	208,029
Manitoba	65,100	479,500
British Columbia	200	1,300

The gypsum industry of Canada consists chiefly in quarrying the crude gypsum, and in shipping it in that condition to the United States, where it is calcined, and in part shipped back to Canada as a finished product.

During the year 1912 nineteen companies were engaged in the quarrying or mining of gypsum, and nine of these produced crude gypsum only. Some of the mines have calcining plants, and in recent years there has been considerable progress in the trade, but there is still much room for progress as regards refinement of the gypsum, as is shown by the large amount of the finished product imported from the United States.

The gypsum occurs in beds of Palæozoic age, partly in the Devonian and partly in the Carboniferous. Nova Scotia is the province in which it has been most extensively mined, and there the gypsum occurs associated with limestone and anhydrite in beds of Carboniferous age. The gypsum of Nova Scotia is chiefly of the massive variety, though veins of selenite occur in it. The gypsum rests on a floor of anhydrite and encloses lenticular masses of the latter mineral.

The publication deals in some detail with the technology and uses of gypsum and includes an account of *The Gypsum Deposits* of the Maritime Provinces by W. F. Jennison.

Molybdenum Ore.—According to a memorandum supplied to the Imperial Institute by the High Commissioner for the Union of South Africa, molybdenite is found associated with granitic rocks in various parts of the Union. In the Cape Province it is found at Helderberg (near Cape Town) and Kamiesberg (Little Namaqualand). It is also found associated with copper ore at Tweefontein, Narrap, Nababeep, and New Prospect, in Little Namaqualand. In the Transvaal it is found at Appingendam and Stavoren (Waterberg district); and at Enkeldoorn and Houtenbek

(Pretoria district). In Natal it occurs at Dumisa in Alexandra county, Umkukuse and Subeni in Zululand, and at Impendhle near the source of the Umkomanzi river in the foot-hills of the Drakensberg.

Of these occurrences only those at Stavoren, Houtenbek, and Impendhle are worthy of note.

At Stavoren, molybdenite is found associated with tinstone in a red granite. The amount of molybdenite appears to be too small to make it worth mining alone, but 3½ tons of material, containing 15 per cent. of molybdenite, was sorted from a dump and shipped to Europe in February 1915.

At Houtenbek, molybdenite occurs in quartz veins traversing red granite, in the neighbourhood of veins carrying monazite. No work has been done up to the present, but the molybdenite occurrence at this locality appears to be promising enough to be worthy of attention.

The deposit at Impendhle is a horizontal bed of pyritic sandstone from 3 to 4 ft. thick, containing molybdenum equivalent to nearly 5 per cent. of molybdenite, partly in the form of fine scales, and partly in the form of a soluble alteration product. Up to the present there has not been sufficient work done to prove the extent of the deposit, but outcrops are stated to extend over a distance of several miles, and the occurrence is one worthy of closer examination.

According to information supplied by the Canterbury Chamber of Commerce, molybdenum ores have been reported from the following localities in New Zealand: Tararu Creek, near the Thames; Richmond Hill, near Parapara; Fourteen Mile Creek, near Greymouth; the Paparoa Ranges; Bravo Island, near Stewart Island; near Dusky Sound; and Mount Radiant in West Nelson. So far as is known at present, however, the deposits at these localities are, for the most part, insignificant in size, and the most promising occurrence is that at Mount Radiant. The Mount Radiant deposits are described by E. J. H. Webb in *Bulletin* No. 11. (*New Series*), *Geol. Surv. of New Zealand*, 1910, p. 26, as a vein-formation at least 66 ft. in width, consisting of a series of more or less parallel veins from 4 in. to 3 ft. in thickness, with small ramifying veinlets, the whole presenting the appearance of a stockwork. At one locality the vein-formation is exposed continuously over a distance of 150 ft. The veins appear to be of pegmatitic origin, and pass into a typical pegmatite. The country rock is a biotite-muscovite-granite. Molybdenite is the most conspicuous ore mineral, but associated with it are chalcopyrite, bornite, and pyrite. A "general" sample gave the following assay: gold, 8 gr. per ton; silver, about 18 dwt. per ton; copper, 1·01 per cent.; and molybdenum, 0·34 per cent. A picked sample gave: silver, about 20 oz. per ton; copper, 3·42 per cent.; molybdenum, 3·72 per cent.,

equivalent to 6·2 per cent. of molybdenite. One of the numerous veins of the Mount Radiant Reef is stated to carry 1·2 per cent. of copper and 1·76 per cent. of molybdenum. The Mount Radiant copper-field as a whole is described in the *Bulletin* as essentially a low-grade copper proposition at the prospecting stage of development. It is situated in the Westport Division, which is in the south-west of the Nelson Land District, a remote, mountainous part of New Zealand.

Petroleum.—During recent years much interest has been displayed in South Australia in the possible existence of petroliferous strata. The subject was dealt with by Mr. L. Keith Ward, the Government Geologist of South Australia, in a Survey *Bulletin* (No. 2) issued in 1913. Mr. Ward examined the supposed petroliferous strata on Kangaroo Island and on the western coast of Eyre's Peninsula, but reported that he was unable to find evidence of the existence of oil-bearing strata in these areas (see this BULLETIN, 1913, **11**, 517). These and other areas have recently been examined by Messrs. A. Wade and L. L. Wrathall, and a report of their work by Dr. Wade has now been published (*Bulletin* No. 4, *Geol. Surv. of S. Australia*, 1915). This report confirms the conclusions arrived at by the Government Geologist.

The areas dealt with in the report include Eyre's Peninsula, Kangaroo Island, Yorke Peninsula, and the South-Eastern District.

It is inferred that the chances of obtaining a supply of petroleum from these districts are very slight. Of many hundreds of boreholes that have been made in search of water at different times and in different parts of the State, only two have given even the slightest indication of interest from a petroleum standpoint. One of these showed only traces of oil, the other revealed the presence of shale which may possibly produce oil on distillation; but in both cases the bores were carried deep enough to show that the strata were of no economic importance as regards petroleum.

Tungsten Ore.—According to information received at the Imperial Institute from the Canterbury Chamber of Commerce, scheelite (calcium tungstate) is widely distributed in the South Island of New Zealand. This valuable ore mineral of tungsten is at present found chiefly in Central Otago and in the Wakamarina valley in the north of Marlborough. In Central Otago it occurs over a considerable area of country extending from Lake Wakatipu in the west to the neighbourhood of Palmerston in the east, notably near Glenorchy, and in Macrae's district. In the latter district the scheelite occurs in quartz reefs associated with gold. The chief mine is near Glenorchy, and the ore obtained there yields concentrates containing 70 per cent. of tungstic oxide (WO_3).

The mineral wolframite (tungstate of iron and manganese) also occurs in New Zealand, as in Stewart Island and in West Nelson, but hitherto it has not been found in sufficiently large quantities to be worth mining.

The total yield of tungsten ore in New Zealand during 1913 was 221 tons, valued at £22,933, compared with 135 tons, valued at £13,347, during 1912.

NOTICES OF RECENT LITERATURE

First Principles of Production. By J. Taylor Peddie, F.S.S. With Contributions by S. Roy Illingworth, Sir Norman Lockyer, Dr. W. Lorimer, and Prof. P. Frankland. Pp. vi + 231, Demy 8vo. (London: Longmans, Green & Co., 1915.) Price 5*s.* net; post free, United Kingdom 5*s.* 4*d.*, abroad 5*s.* 5*d.*

This book was written with the object of persuading British manufacturers that in general their methods are not those which give maximum efficiency, and that they would do well to enlist the services of scientific men to a far greater extent than they have done hitherto. Of the twelve chapters, eight are contributed by Mr. Peddie. Dr. Lorimer deals with the opportunities offered to the British steel maker by the outbreak of the war, and mentions some of the difficulties which have led to the gradual decline of Great Britain to third position among steel-making countries, and to a production which is little more than a third of Germany's output of steel. Mr. Roy Illingworth writes on the Co-operation of Science and Industry. The contributions by Sir Norman Lockyer and Prof. Frankland are reprints of addresses.

There are many small points in this book to which one might take exception, but against the general principle, which underlies all that is said, no objection can be raised. The authors see every process of manufacture as a continual experiment, which can only be carried on satisfactorily under the supervision of competent scientific observers, who are permitted to modify it in the direction of increased efficiency. To this thoroughly modern conception of factory organisation no objection is likely to be raised by those best qualified to judge. Indeed, it is fairly safe to say that it is accepted by most of the larger British manufacturers, and that some of them have run their factories on these lines for years past. In the great majority of cases, however, these ideas have not been put into practice, and it is by no means uncommon to find manufacturers, thoroughly convinced of the soundness of these ideas, declining to put them into operation because their particular industries are not yet threatened by foreign competition.

The provision of scientific assistance in industry is,

however, not such an easy matter as most of those who preach to manufacturers on the subject suppose. In this connection it may be pointed out that those manufacturers who have re-organised their factories, and now work them successfully on modern lines, have usually found it necessary to select and train their own technological experts. There is plenty of evidence that the British universities and technical colleges fail as completely now in providing the technical assistance required by manufacturers as they did in 1874, when the late Sir W. H. Perkin disposed of the first British aniline dye factory, largely because it was impossible to obtain the trained men he required. It is difficult to see how this is to be remedied unless university teachers will begin to take a more intelligent interest in training men for industry instead of giving their keenest attention to the students who take naturally to teaching, as a profession, which will afford them time for the prosecution of academic research. This difficulty is not altogether lost sight of in this book, but it would have done no harm to insist more strongly on the fact that the British universities must share with the manufacturers the blame for the absence of scientific advisers in many British factories.

A book of this kind is useful at the present juncture, when many British manufacturers are in the unpleasant position of no longer being able to get supplies of materials of various kinds from Germany, and have therefore been led to consider the whole question of their manufacturing conditions and sources of supply. From this point of view it is unfortunate that the book devotes more attention to lecturing the manufacturer than to giving him suggestions as to what he should do.

When a new edition is called for, attention might well be given to this point, and at the same time such statements as the following might receive the revision which they clearly require: "In Great Britain we can make no comparison, for we have *no chemical industries* to speak of" (Mr. Peddie, p. 46). "In our days all improvements and new inventions emanate from abroad" (Mr. Illingworth, p. 83).

Forage Plants and their Culture. By Charles V. Piper. Pp. xxi + 618, Crown 8vo. (New York: The Macmillan Company, 1914.) Price *7s. 6d.* net; post free, United Kingdom *7s. 11d.*, abroad *8s. 3d.*

Owing to the exceedingly diversified climatic conditions in North America, an unusually large number of plants are cultivated for the production of forage. Numerous grasses and leguminous plants have been introduced into the United States from all parts of the temperate and sub-tropical regions of the world with a view to securing plants capable of profitable cultivation. As a result, a large number of forage crops, almost unknown in Europe, are widely culti

vated. The author of the present book, in his position of Agrostologist in charge of forage crop investigations in the Bureau of Plant Industry of the United States Department of Agriculture, has had exceptional opportunities for studying these crops, and perhaps no person is better qualified to produce a treatise on this subject.

The earlier chapters of the book deal with general matters, such as the characteristics of forage plants, the preservation of forage as hay and ensilage, the choice of forage crops for different conditions, feeding values, seed testing and sowing, and the formation of meadows and pastures. The first few pages, giving the definition of terms used in the United States, will be specially welcomed by readers outside that country. The greater part of the book is occupied with a detailed account of all the most important forage crops grown in the United States, and briefer references to the less important. As illustrating the method of treatment followed, the chapter dealing with timothy grass, the most important hay grass grown, may be referred to. This deals with the botany of the plant, its agricultural history, climatic and soil conditions, preparation of seed bed, rate and method of sowing, manuring, yields, vegetative characters, feeding value, pests and diseases, breeding, field trials with improved strains, etc. Other grasses are dealt with in a similar manner, and then follow accounts of leguminous crops, such as alfalfa (better known in this country as lucerne), red clover, peas, vetches, cowpeas, and soy beans, miscellaneous herbs, including prickly pear and Australian saltbush, and root crops.

The book is essentially practical throughout, and although specially written from the point of view of the American farmer, it should prove of great value in all countries where these crops are grown.

Australia versus Germany. By F. S. Burnell. Pp. 254. (London: George Allen & Unwin, Ltd., 1915.) Price 3*s*. 6*d*. net; post free, United Kingdom 3*s*. 10*d*., abroad 3*s*. 11*d*.

This is an account of the capture of German New Guinea by the Australian Expeditionary Force, the author having accompanied the force as correspondent of the *Sydney Morning Herald*. Mr. Burnell points out that the book was "written in great haste and under circumstances of no small difficulty," and as a matter of fact it is little more than a bald record, with the addition, however, of some interesting photographs. But he states with complete truth that "the first war waged single-handed by Australia merited a chronicler," though as a matter of fact an account of the operations of the Australian Naval Squadron will be required to make any such story complete.

"By coconuts and copra," Mr. Burnell points out, "the German possessions in the Pacific have commercially lived, and had their being."

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

INDIAN OPIUM

A SYSTEMATIC investigation of the opium produced in India has been conducted at the Imperial Institute with the object of ascertaining the composition of the drug from different parts of the Indian Empire and its suitability for use in European medicine. The results of the work accomplished hitherto are incorporated in the present article. Since the outbreak of war the Government of India has permitted the export of a certain quantity of opium to this country for the use of morphine manufacturers.

Opium is obtained from the capsules of the opium poppy, *Papaver somniferum*, Linn. When incisions are made in the unripe capsules, a milky juice or latex exudes and collects in the form of tears on the edges of the cut surfaces. After being left for about eighteen to twenty-four hours, the partially dried latex is scraped off the capsules by means of a blunt knife. When sufficient opium has been accumulated in this manner, it is made into the form of a cake and further dried by exposure to the sun. Details of the methods of preparation practised in India are given on page 516. In Asiatic Turkey, the cakes are wrapped in poppy leaves. In India, the opium is either coated with poppy petals and "trash" (crushed poppy stalks and leaves) or is wrapped in oiled paper. In Persia, the cakes, which are generally of a short, bluntly conical form, are usually wrapped in paper.

The chief sources of opium are the region formerly included in European Turkey (especially the Salonica

district), Asiatic Turkey, Persia, and India. Large quantities of the drug were formerly produced in China, but during recent years the cultivation of the opium poppy has been severely restricted by the Chinese Government. Poppies are cultivated for opium to a small extent in Upper Egypt. It is stated that during the last few years they have been grown on an area of one or two acres in Victoria, Australia, but the total quantity of opium produced during the years 1908–12 was only 89 lb.

The following table shows the quantities and value of the imports of opium into the United Kingdom during the years 1913 and 1914:

From	1913.		1914.	
	Cwts.	£	*Cwts.*	£
Hong Kong	339	38,102	267½	26,426
Persia	1,219	142,852	2,330	247,464
Asiatic Turkey	1,940	174,878	2,690	242,045
European Turkey	1,387	133,858	1,362	126,588
Other countries	176½	17,572	1,030½	94,159
Grand Total	5,061½	507,262	7,680	736,682

The exports of opium from India and other producing countries are given below:

Exports of Opium from India

To	1911–12.		1912–13.		1913–14.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Ceylon	177	20,922	73	6,813	156	15,845
Straits Settlements	9,795	1,099,801	7,473	704,870	2,255	226,500
Hong Kong	17,055	3,019,858	10,844	2,406,084	5,023	1,084,093
Java	3,219	362,120	4,415	383,408	4,789	472,199
Siam	1,681	190,657	2,692	263,177	1,656	164,030
Indo-China	3,115	325,500	1,180	99,018	1,282	129,502
China	17,142	3,614,887	12,905	3,242,907	111	27,833
Macao	—	—	2,457	236,420	220	18,295
Japan	624	76,817	1,392	129,545	1,170	119,913
Other countries	137	15,498	74	8,846	196	21,821
Total	52,945	8,726,060	43,505	7,481,088	16,858	2,280,031

The total exports of opium from Turkey during the year March 1911 to February 1912 were 306 tons, value £692,000, of which 183 tons, value £412,000, came to the United Kingdom.

The value of the exports of opium from Persia in the year 1912–13 was £634,807, as compared with £409,103 in 1911–12, and £239,454 in 1910–11.

There were no recorded exports of opium from China in 1913. The exports had fallen in 1912 to 666 lb., value £746.

The Composition of Turkey and Persian Opiums

Turkey Opium

The opium produced in Turkey is the most important medicinally and the most widely known in the markets of the world. The Asia Minor drug is chiefly marketed through Smyrna, and that from "European Turkey" is exported from Constantinople and Salonica. Smyrna opium is known commercially under different names, according to the particular districts in which it is produced, and the various classes differ in quality and physical characters. "Boghaditz" opium is derived from the district of this name lying north of Smyrna; it is considered the richest opium obtainable in Asia Minor, but it is very gummy. "Yerli" opium is that produced in the districts surrounding Smyrna (excepting Boghaditz); it is very soft and is reputed to contain about 13·5 per cent. of morphine. "Karahissar" opium is derived from a district in the interior of Asia Minor with the town of Karahissar as its centre. The "Adet" variety, sometimes known as "jobbing opium," is the inferior opium from all districts in Asia Minor.

The opium marketed through Salonica contains from 10 to 14 per cent. of morphine. "Tokat" and "Malatia" opiums, from districts of the same names located in Armenia, are sold in the Constantinople markets for export to Cuba, West Indies, and Central and South America. The amount of morphine in these opiums varies from 7 to 14 per cent.

The recorded amounts of morphine in Turkey opium show great variation, mainly due, no doubt, to the variable composition of the drug, but also in part to the different

methods employed by investigators in determining the morphine. On the whole, however, Turkey opium seems to contain more morphine than opium from other sources. On the other hand, the quantities of narcotine and codeine in Turkey opium appear to be less than those contained in the Persian and Indian varieties.

Persian Opium

The most important commercial varieties of Persian opium appear to be the so-called Mesched and Ispahan opiums. As a rule good Persian opium contains from 12 to 13 per cent. of morphine; the poorer quality opium, such as for example that from Burugird, containing only 7½ to 8 per cent., is not used for direct exportation, but for local consumption and for mixing with such opium as contains more than the required quantity of morphine.

Persian opium is preferred to the Turkish drug for the manufacture of codeine, as it contains on the average 2½ per cent. of that alkaloid. The figures recorded for narcotine in Persian opium vary from 2·5 to 8·37 per cent.

Pharmacopœial Requirements for Opium in Different Countries

British Empire.—In considering the results recorded in this report it is necessary to bear in mind the standards of quality required for opium used medicinally in the United Kingdom and elsewhere. The British Pharmacopœia (1914) requires that opium employed for preparing tincture and extract of opium must contain when dry not less than 7½ per cent. of anhydrous morphine, but when otherwise used for officially recognised purposes it must contain when dry not less than 9½ per cent. and not more than 10½ per cent. of anhydrous morphine. Also, opium containing more than 10 per cent. of morphine may be diluted to that percentage with any opium containing when dry not less than 7½ per cent. of morphine. It follows, there-

fore, from these restrictions, that only opium containing 7½ per cent. or more of morphine may be used for making the official preparations of the British Pharmacopœia.

The amount of morphine in opium required by other countries is as follows:

United States.—The opium in its normal moist condition must yield not less than 9 per cent. of crystalline morphine.

For "opium granulatum," *i.e.* opium dried at a temperature not exceeding 85° C. and reduced to a coarse powder, the standard is 12 to 12½ per cent. of crystalline morphine.

The United States official assay method was found at the Imperial Institute to give results with Indian opium about 1 per cent. less than those afforded by the method of the British Pharmacopœia (1898).

France.—There must be from 10 to 11 per cent. of morphine in the drug dried at 60° C.

Germany.—The standard required is at least 12 per cent. of anhydrous morphine in the drug dried at 60° C.

Japan.—The dry opium must contain from 10 to 11 per cent. of morphine. The Japanese official method for the assay of opium is similar to that of the British Pharmacopœia, but no correction for loss of morphine is made as in the British Pharmacopœia.

Narcotine is present, in small quantities, in all medicinal opium, and there are no pharmacopœial restrictions limiting its amount, but the presence of so large a proportion as exists in some Indian opiums may be considered disadvantageous.

Opium in Medicine

The medicinal value of opium is mainly due to the morphine contained in it, and in general the action of the drug is similar to that of the alkaloid.

Of the opium alkaloids only morphine and codeine are used as such to any great extent in medicine; narcotine is employed for the manufacture of cotarnine which is also a medicinal agent. Codeine resembles morphine in the general

features of its action, although it is much less poisonous and is preferred in some diseases, for example, diabetes, where it has a greater power in controlling the excretion of sugar. Narcotine is a much less poisonous alkaloid than either morphine or codeine, and large quantities have been administered repeatedly with little or no narcotic effect.

In addition to the direct use of opium in medicine, as tincture and extract, a large quantity of opium is employed in Europe for the extraction of the alkaloid, morphine, and also for the extraction of codeine.

The Opium Industry in India

Indian opium was formerly exported from both Calcutta and Bombay. That from Calcutta, known as "Bengal opium," is grown in the United Provinces and in Bihar and Orissa. The drug which used to be shipped from Bombay is termed "Malwa opium," and is produced in Baroda and certain of the Native States of Central India and Rajputana. Bengal opium is derived mainly from white-flowered races of the poppy, whilst Malwa opium is largely obtained from plants with purple flowers. The exports of opium from Bombay have now ceased, owing to the fact that the Government of India have prohibited the passage of Malwa opium into British territory. In certain areas of the United Provinces, known as monopoly districts, the opium cultivator is required to obtain a licence, and is granted advances to enable him to prepare his land for the crop. The whole of the opium produced in these districts must be delivered to Government agents at a fixed price and is despatched to the Government factory at Ghazipur, where it is graded and prepared for export, and some of it employed for the extraction of morphine and codeine.

Some years ago, large quantities of Indian opium were regularly exported to China (see table on p. 508). Towards the close of 1906, however, the Chinese Government issued edicts ordering that within ten years the growth and consumption of opium in China must be suppressed. In 1907, an agreement was concluded that the amount exported to China from India should be reduced annually, and in 1913 the sale of opium to China was brought to an end.

The area devoted to opium cultivation in India has decreased gradually from about 769,000 acres in 1903-04 to about 241,000 in 1912–13.

EXAMINATION OF INDIAN OPIUMS AT THE IMPERIAL INSTITUTE

In 1896, in consequence of the results of analyses of Indian opium made at the Imperial Institute and of the favourable results of preliminary trials of Indian opium for medicinal purposes which were instituted at St. Thomas's Hospital, the Director of the Imperial Institute drew the attention of the Government of India to the possibility of employing Indian opium in European medicine. The Government of India were however then of opinion that any attempt to introduce Indian opium into Europe might prejudice the existing trade with China. In 1907, however, the question was again revived in view of the restrictions which were imposed on future trade with China, and it was proposed to submit to investigation samples of opium from the chief districts in India with a view to the determination of their fitness for medicinal use and for the manufacture of alkaloids. This proposal met with the approval of the Government of India.

The present report relates to the results of a very complete investigation of the composition of Indian opiums. It has involved the chemical examination of a large number of samples of opium, some collected in 1896 and others in 1909.

The samples collected in 1896 were examined chiefly for another purpose, which is referred to later (see p. 516), but these results are available for the end to which the later enquiry was directed, viz. to determine to what extent Indian opium is suitable for use in European medicine and for the commercial extraction of morphine and codeine.

The results now presented prove that about half of the opium represented by the samples collected in 1909 could be substituted for the best Turkey and Persian opium now employed in European medicine, whilst in addition 25 per cent. more could be used for special medicinal purposes

for which a smaller proportion of morphine in the opium is sufficient. Some Indian opium is exceptionally rich in alkaloids. Nearly all Indian opium could be used for the extraction of morphine, and some of it is also particularly suitable for the extraction of codeine.

The present results refer to the opium now being produced in India. Considerable improvements are possible in the methods of production and preparation at present practised, and if these were carried out a still larger amount of Indian opium would become suitable for medicinal purposes.

There would be no difficulty in selling Indian opium, as at present produced, to European manufacturers of opium alkaloids (morphine and codeine), who would purchase it at a price depending on the percentage of these two alkaloids present. The current price in London is about 35*s.* per lb. for Turkey opium containing 11 per cent. of morphine. This unusually high figure was attained when Bulgaria became involved in the European war, the price on September 18, 1915, being only 23*s.* to 24*s.* per lb. In the early part of 1914 this grade of opium was quoted as low as 15*s.* per lb. The present price of Persian opium containing 10 per cent. of morphine is 22*s.* 6*d.* per lb., the price early in 1914 being about 20*s.* per lb.

In order to encourage a trade in Indian opium, it would be desirable that a complete study should be made in India of the production and cultivation of the varieties of poppy best adapted to furnish opium of the quality desired. The subject is dealt with as fully as possible in the present report, and it is evident that certain varieties at present grown in Central India and in the United Provinces should receive first attention. A considerable amount of experimental work would be needed, especially in order to ascertain the results of growing a particular variety in a new district. There is evidence that the same variety grown under different conditions of soil, climate, and cultivation may furnish opium of different quality.

In connexion with the preparation of opium it is clear that Indian procedure could be considerably improved, and for this purpose a careful investigation is desirable of

the procedure followed in Turkey, with regard to which the Director of the Imperial Institute made preliminary enquiries during a visit to Asia Minor for the Colonial Office in 1907. While such investigations are being carried on, however, it would be well to encourage the use of certain Indian opiums, as at present produced, for medicinal and manufacturing purposes in Europe.

Origin of the Opiums examined

It has been pointed out on page 513 that the present investigation is the outcome of recommendations made by Professor Dunstan to the India Office in 1907 with respect to the possibilities of developing a European trade in Indian opium for medicinal purposes and for the extraction of morphine and other alkaloids. In accordance with these recommendations samples of opium were collected in various opium-producing districts of the Punjab, United Provinces of Agra and Oudh, Rajputana, Bihar, and Central India (Malwa portion), and forwarded to the Imperial Institute for chemical examination. Altogether 102 samples of opium, together with botanical specimens of the poppies, were received, and notes were supplied dealing with the cultivation of the plants and the collection and preparation of the opium in the different districts.

The samples of opium had been collected in small quantities from a number of different "varieties" of poppy, and hence only represented crude opium and not the drug as specially manufactured for export. The results of the analyses do not therefore show the composition of Indian opium as it would appear in trade, but that of a material which could be considerably improved.

Although this report is mainly concerned with the results of the examination of the opiums already referred to, and which began to be received at the Imperial Institute towards the end of 1909, it has been thought advisable to include also the general results of the examination of a similar set of 44 samples of Indian opium forwarded to the Imperial Institute in 1896 at the instance of the Government of India.

Effect of Different Methods of Preparation on the Composition of Opium

The specimens of opium received from India in 1896, which were obtained from Bihar, Benares, Central India, Rajputana, and the Punjab, had been specially collected in order to determine the effect on the composition of the drug of the variations in the methods adopted in the different districts of India for the growth of the poppy and the collection and preparation of the opium. The results of the investigation of these samples clear up a number of points as to which information was desired, but they are only to be regarded as introductory to the more complete investigation with which the present report chiefly deals. It will therefore be convenient to refer briefly to these results here, and to consider later any points in common with the more recent samples under their appropriate headings.

As regards the preparation of the opium, the earlier enquiry was directed to ascertaining how far the practice of removing from the opium the "pasewa," a watery fluid which accompanies the opium as collected under certain climatic conditions, and the subsequent operation of partially drying the opium by exposure on porous earthenware plates, may be responsible for a loss of alkaloid; and in the case of the Malwa opium, whether the treatment by immersion in linseed oil, which is peculiar to Central India, is prejudicial to the quality of the opium.

Influence of the Removal of Pasewa

The results on this point are inconclusive, as they indicate that the removal of the pasewa is responsible in many cases for a loss of alkaloid, whilst in others the opium containing pasewa gave the lower percentage of alkaloid. This is illustrated by the following analyses of the samples of opium from the Bihar and Benares Agencies:

Bihar Samples

	Percentage of morphine, on dried material.		
	Opium with pasewa.	Opium without pasewa.	Difference.
From Aliganj (Nos. 6,260 and 6,261)	6·66	5·15	+1·51
From Shahabad:			
White-stemmed poppy (Nos. 6,263 and 6,266)	7·95	7·00	+0·95
Black-stemmed poppy (Nos. 6,264 and 6,267)	8·91	4·53	+4·38
Cajaria (Nos. 6,265 and 6,268)	7·15	6·15	+1·00

Benares Samples

	Percentage of morphine, on dried material.		
	Opium with pasewa.	Opium without pasewa.	Difference.
Opium from Chukania poppy (Nos. 6,047 and 6,048)	9·03	10·58	−1·55
Opium from Kala-danti poppy (Nos. 6,049 and 6,050)	8·69	9·74	−1·05
Opium from Katila poppy (Nos. 6,051 and 6,052)	8·69	13·89	−5·20

It will be observed that in the Bihar samples the opium containing pasewa yielded in every case more morphine than the corresponding sample from which the pasewa had been removed, whilst in the Benares samples the results are exactly the reverse. The reason for this difference is not apparent.

The reason given for the separation of pasewa from opium is that if allowed to remain it injures the physical characters of the drug, causing it to become black and liquid. Pasewa consists of the most soluble of the constituents of opium, dissolved in dew or in moisture absorbed from the atmosphere; it has a peculiar smell, and is strongly acid in reaction. It contains meconic acid, resin, morphine, and narcotine.

Unfortunately no specimens of pasewa were forwarded to the Imperial Institute for examination. The analyses of pasewa on record show great variation in the amounts of morphine and narcotine present, ranging from 0·78 to

3·19 per cent. of morphine, and from 2·73 to 8·23 per cent. of narcotine.

The amount of pasewa present in crude opium is very variable, its formation apparently depending upon special climatic conditions, the chief of which is excessive humidity of the soil and atmosphere, for in a dry season it is reduced to a minimum. The extent of its occurrence may perhaps be approximately gauged by a comparison of the amounts of opium and pasewa brought in by the cultivators, and the figures for the Bihar and Benares Agencies during the ten years 1890 to 1900 show that the amount of pasewa fluctuates in a remarkable manner. In relation to the opium it was highest in both Agencies during the season 1892-1893, when it was 1·19 per cent. in Bihar and 0·9 per cent. in Benares; the minimum yield in both Agencies was during the season 1894-95, when it amounted to only 0·13 per cent. in Bihar and 0·047 per cent. in Benares. These figures are no doubt too low, for it is certain that the whole of the pasewa is not brought in by the cultivators, yet unless the total quantity is much greater than the foregoing figures would suggest, or unless it usually contains more morphine than the highest recorded quantity, *i.e.* 3·2 per cent., it is difficult to believe that its removal can cause any serious diminution in the percentage of morphine in the opium. If such were the case, it would be anticipated that the opium of a season in which the quantity of pasewa was relatively large would be low in morphine, and *vice versa*, but the figures on record do not exhibit any correlation between the amount of pasewa produced and the percentage of morphine in the opium.

Influence of drying Opium on Porous Plates

The other possible source of loss of alkaloid is the absorption of liquid by the porous vessels used in separating the pasewa or storing the opium. In most cases the drying of opium on porous plates leads to the loss of alkaloid and also of extractive matter. The results, though somewhat ambiguous in some instances, show that this loss may be appreciable, and also that different varieties of

opium do not behave in the same manner in this respect. These results have been confirmed by a special series of experiments, in which the proportion of alkaloid removed from moist opium by exposure on a porous plate has been determined, and it has thus been shown that the extent of the loss of alkaloid by solution in water and by absorption in porous earthenware depends on the variety of opium.

Influence of the Use of Oil in the Collection of the Crude Opium

The method of collecting opium usually adopted in the Central Provinces (Malwa) and Rajputana differs essentially from that followed in the case of the Bengal opium, and may be briefly described.

The opium is removed from the capsule with an iron scraper, on which is fastened a pad of cotton saturated with linseed or poppy-seed oil; the collector also keeps his thumb smeared with the oil to assist in the removal of the drug. This, as soon as collected, is placed in a small pot containing oil, and is afterwards transferred to larger earthen vessels for storage, more oil being added so that it is completely covered.

In Malwa linseed oil is usually employed, in the proportion of two parts of oil to one of crude opium, and the opium is kept beneath the oil until it is sold, after which the oil is removed as completely as possible by suspending the opium in bags for a month or six weeks, and allowing the oil to drain away. In the subsequent manufacture of the cakes a little more of the oil is worked out by kneading, and the remainder dried with the opium. In this method of collection no special provision is made for the removal of pasewa from the crude opium, but it is supposed to drain away along with the oil.

In Rajputana poppy-seed oil is employed in the Mewar district, while linseed oil, as in Malwa, is used in the Kotah State.

It was thought possible that in this method of preparation the oil might carry with it a considerable amount of

alkaloid, and in order to investigate this question samples of opium were prepared in several different ways. From the Central Provinces three sets of specimens were sent, from Bhopal, Ujjein, and Indore respectively, each of which comprised samples collected in four different ways from the same field. Two of these corresponded with the methods adopted in the case of Bengal opium, viz. (1) crude opium collected without oil in glazed vessels and undrained, and (2) crude opium collected without oil in porous vessels and drained; and in the other two cases oil was employed in different ways, viz. (3) crude opium collected with oil in glazed vessels and undrained, and (4) crude opium collected with oil and soused in oil, in the ordinary Malwa fashion. In addition, a sample of the oil which had drained from opium treated in the usual Malwa way was sent from Ujjein.

The following table gives the results obtained:

Central India Agency

	Percentage of morphine in dried opium.		
	From Bhopal.	From Ujjein.	From Indore.
1. Crude opium collected without oil in glazed vessels and undrained .	8·86	11·43	4·94
2. Crude opium collected without oil in porous vessels and drained .	5·34	11·71	6·22
3. Crude opium collected with oil in glazed vessels and undrained .	6·94	2·42	5·52
4. Crude opium collected with oil and soused in oil, ordinary Malwa fashion	5·10	5·15	3·57

The opium oil from Ujjein was found to contain 1·4 per cent. of total alkaloid, made up as follows: narcotine, 0·7; papaverine, 0·3; codeine, 0·1; and morphine, 0·3 per cent.

From the different districts of the Rajputana Agency two comparable samples were sent in each case: one collected without oil in a non-porous vessel and dried without drainage, and the other collected with oil in the usual way. The following are the results of the analyses:

Rajputana Agency

	Percentage of morphine in dried opium.			
	Mewar.	Kotah State.		
		Mangrol.	Kishenganj.	Ladpura.
1. Opium collected without oil in non-porous vessel and undrained .	10·89	4·04	12·04	5·45
2. Opium collected with oil in the usual way	10·80	4·56	12·45	6·23

The results yielded by the samples from the Central India Agency indicate on the whole that the method of collection without oil is advantageous, for the highest percentage of morphine is yielded in all three cases by one of the two samples which were not treated in any way with oil; but at the same time the samples No. 3 from Bhopal and Indore which were collected with oil but undrained are intermediate, as regards morphine content, between the two samples (Nos. 1 and 2) collected without oil. The results obtained with the samples from the Kotah State are the reverse of those furnished by the specimens from the Central India Agency, for though the differences are smaller than before, ranging from 0·4 to 0·8 per cent. of morphine, they are in favour of the present native process (cf. p. 530). It would thus appear that in these cases the oil removed certain non-alkaloidal constituents from the opium, raising proportionally the percentage of alkaloids.

The sample of oil from Ujjein which had drained from the opium only contained 0·3 per cent. of morphine, and it seems improbable therefore that the oil can remove any large amount of that alkaloid.

The analytical results furnished by this consignment of opium samples are given in the next section of the report, together with those obtained in the examination of the second series of specimens from the same districts.

Analytical Results of the Examination of Specimens of Opium from India

In the examination of the first series of specimens, received in 1896, the amounts of moisture, morphine, and narcotine were determined in each sample. The morphine was determined by Flückiger's method, which gives somewhat lower results than the process adopted in the British Pharmacopœia (1898), and in cases where the percentage of alkaloid was 10 per cent. or more the results were subsequently confirmed by the method of the British Pharmacopœia. In all cases the amount of morphine present in the opium was determined by the titration of the precipitated alkaloid. The method for determining narcotine was the same as that described below.

In the chemical examination of the second series of specimens the following determinations were made:

(1) *Moisture.*—The loss in weight when dried at 100° C.

(2) *Total aqueous extract.*—The amount of extractive matter soluble in cold water.

(3) *Morphine.*—The method given in the British Pharmacopœia for 1898 was employed.

(4) *Codeine.*—The published methods for the determination of this alkaloid were found to be unsatisfactory, and it became necessary to devise a new method. This involved a great deal of experimental work, and was the cause of considerable delay in the early stages of the investigation. By the method finally devised the codeine is obtained in a crystalline condition, and its purity can be determined by its melting point. A detailed account of the method is given in a paper by Mr. A. E. Andrews of the Scientific and Technical Research Department of the Imperial Institute, published in the *Analyst* (1911, **36**, 489).

(5) *Narcotine.*—As a considerable quantity of this alkaloid is sometimes present in Indian opium it was considered advisable to determine the amount in each sample. The dried opium was extracted with dry ether in a Soxhlet extraction apparatus, and the narcotine was removed from the ethereal solution by shaking with successive quantities

of dilute sulphuric acid; this acid solution was rendered alkaline with ammonia and extracted with ether, on evaporating which the narcotine was obtained in a crystalline condition sufficiently pure to weigh.

The results of the analyses are summarised in the following account which deals separately with the samples from each State or Province. As has been indicated above, the second series of samples was submitted to a more detailed examination and this series will consequently be considered first in each case. The samples of the second series are placed in order of quality, according to the amount of morphine present.

Samples from Punjab

Second Series

No.	Colour of flowers.	District.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2	White	Shahpur (Kurpalka village)	25·4	13·63	3·74	7·43	57·36
5	White, mauve, and red	Kulu (Kangra)	22·74	10·48	2·18	7·04	65·40
4	White	Ambala	25·15	8·90	2·89	11·42	49·22
8	White and red	Lahore	51·9	8·47	2·27	8·03	32·22
7	White	Dera Ghazi Khan	14·39	8·36	3·45	6·13	69·77
3	White	Ambala	17·78	7·67	2·48	6·31	57·68
6	White and red	Simla	43·24	5·72	2·42	7·61	50·14
1	White	Shahpur (Bhera village)	41·72	5·17	2·76	10·61	28·97
	Average			8·55	2·77	8·07	51·3

These samples were distinguished by the colours of the flowers, the varieties of poppy not being given. Sample No. 2 from Shahpur gives very satisfactory figures for morphine, codeine, and narcotine, the morphine reaching the exceptionally high percentage of 13·63. All of these samples, excepting the last two, could be used medicinally; the average percentage of morphine in the first four is 10·37 per cent.

From the information supplied with these opiums it appears to be the practice to extract the crude opium, as

soon as collected, with boiling water, and to evaporate the strained liquid almost to dryness over a fire. The mass thus obtained is therefore not true opium, but really an opium extract. Such an extract should be almost entirely soluble in water, and should contain more morphine than the original opium.

The partial solubility of the samples examined renders it doubtful whether they were prepared in the manner indicated, since the amount of aqueous extract is no greater than that furnished by many crude Indian opiums, or, if so, the conditions were evidently such that a portion of the opium which was originally soluble in water has been rendered insoluble, perhaps through overheating. This drawback could no doubt be obviated.

It appears from notes which accompanied these samples that the methods of cultivation employed in the different districts of the Punjab are the same. The conditions however vary, owing principally to the hilly nature of the province. In the hill districts of Simla and Kulu the rainfall is sufficient for the crop, but in the plains it is very slight, and irrigation by well-water is necessary. Any advantages which the hilly districts may have over the plains, or *vice versa*, for poppy cultivation, are not indicated by the quality of the opiums examined.

First Series

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium. Flückiger's method.
			Per cent.	*Per cent.*	*Per cent.*
6,547	Katha, Shahpur	Crude opium .	7·92	5·63	16·10[1]
6,548	,, ,,	Refined opium .	14·16	1·52	10·12
7,607	Kulu, Kangra	Opium . . .	11·46	4·79	8·52
7,608	,, ,,	Dried juice of the poppy received on poppy leaves	12·66	4·21	7·90

[1] 17·94 *per cent. by British Pharmacopœia* (1898) *method.*

In this earlier consignment of opiums from the Punjab, only one of the four samples was crude opium. This sample was from Katha, Shahpur district, and proved to

be very rich in morphine, containing as much as 17·94 per cent., as determined by the British Pharmacopœia (1898) process; it contained only 5·63 per cent. of narcotine, and is therefore comparable with the best Turkey opium. Unfortunately, the variety of poppy which furnished this opium was not stated.

Samples from the Benares Agency, United Provinces of Agra and Oudh

Second Series

No.	Variety.	District.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1*a*	Harera	Bara-Banki	28·49	11·22	2·84	7·76	66·16
1*b*	Tenia	,,	30·32	11·00	2·82	5·68	69·37
2*a*	Chauripatti Katila	Gonda	33·36	9·73	2·78	6·85	70·00
3*b*	Gulgulua	Ghazipur	31·23	9·07	3·91	5·58	69·80
3*a*	Bhagaulia	,,	30·72	9·03	3·89	5·50	70·39
4*a*	Harania	Bareilly	29·66	8·96	3·96	5·78	70·06
4*b*	Bonnea Safaida	,,	29·49	8·58	3·24	6·07	68·33
2*b*	Patli Katila	Gonda	31·34	8·10	2·95	6·18	68·55
	Average			9·46	3·3	6·2	69·08

From these results it is seen that each pair of samples from the districts of Bara-Banki, Ghazipur, and Bareilly are similar in composition, although derived from different varieties of poppy, which tends to show that the quality of the opium is dependent more on the local conditions prevailing in these districts than on the particular variety cultivated. The good results obtained in the Bara-Banki district may in some measure be due to the use as manure of a saline earth called "Monamath," in addition to cattle dung, as this is the chief difference in practice in these districts recorded in the notes supplied with the samples.

The first five of these samples could be blended to contain 10 per cent. of morphine in the dry opium, whilst the remaining three samples when dry contain more than

sufficient morphine to justify their use for the preparation of tincture and extract of opium. It is noticeable that the amount of narcotine present in the samples is low, and the percentage of aqueous extract high, both important points in favour of these opiums. The average percentages of morphine and codeine are also satisfactory, especially in the case of the latter alkaloid.

First Series

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium.	
					Flückiger's method.	B.P. (1898) method.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
6,047	Sitapur	Crude opium from Chukania poppy; pasewa not extracted	14·93	6·37	9·03	—
6,048	,,	Crude opium from Chukania poppy; pasewa extracted .	7·82	6·34	10·58	11·58
6,049	,,	Crude opium from the Kala-danti poppy; pasewa not removed	18·70	6·54	8·69	—
6,050	,,	Crude opium from the Kala-danti poppy; pasewa removed .	6·81	5·91	9·74	—
6,051	,,	Crude opium from Katila poppy; pasewa not extracted .	20·30	8·83	8·69	—
6,052	,,	Crude opium from Katila poppy; pasewa extracted . .	10·56	8·20	13·89	14·91
6,039	Fategarh	Opium evaporated in the sun on non-porous vessel . .	21·09	7·82	13·48	17·93
6,040	,,	Opium prepared by cultivators in the ordinary way . .	27·76	8·56	—	10·80
Average				7·32	9·69	

These analyses show that the first series of specimens from the Benares Agency were also of good quality. All the specimens contained over 8·5 per cent. of morphine, whilst specimens No. 6,052 from Sitapur and No. 6,039 from Fategarh gave 14·9 and 17·9 per cent. of morphine by the British Pharmacopœia (1898) method. The variety of poppy in the latter case was not stated.

Samples from Kotah State, Rajputana

Second Series

No.	Variety.	From.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
2	Gotia .	Bakani . .	10·78	14·52	3·16	7·14	65·79
6	Nakumri	Manoharthana	17·14	13·18	3·16	6·98	58·91
4	Katra .	,,	21·17	11·85	3·41	6·19	63·49
5	Kantalia	,,	18·76	9·64	2·46	6·18	61·97
3	Gotia .	,,	19·52	9·29	3·09	5·13	49·40
1	,, .	Bakani . .	19·82	8·64	2·39	5·14	54·17
	Average			11·2	2·94	6·1	59·0

These samples are as a whole the best of the opiums received at the Imperial Institute from India. The "Gotia" sample, No. 2, contains the highest percentage of morphine found in the opiums from Kotah and also in all those of the 1909 series. The average percentage of morphine in the six samples is very satisfactory, as it amounts to over 11, and this, coupled with the high percentage of codeine and the relatively low percentage of narcotine, makes these opiums particularly valuable for medicinal purposes.

It is curious to note the great variation in the composition of the three "Gotia" samples, especially as two of these were from the same district. It would appear again that the quality of the opium is not always dependent on the variety of poppy grown.

The favourable results obtained with the "Gotia" variety, taken in conjunction with the statement "that this variety is extensively grown, as it yields a comparatively greater quantity of opium," show the importance that must be attached to this variety in considering the question of the improvement in quality and yield of Indian opium. Although the method of collection and preparation of opium in Kotah is similar to that practised in Malwa in so far that linseed oil is used, yet there appears to be an important difference, for in Malwa the crude drug is immersed in oil during the time of storing, whereas in Kotah it is simply mixed with oil and kneaded into balls. It thus

appears that the oil is used to a much more limited extent in Kotah than in Malwa, and this may account, at any rate in part, for the better quality of the drug from the former State.

First Series

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium.	
					Flückiger's method.	B.P. (1898) method.
			Per cent.	Per cent.	Per cent.	Per cent.
6,504	Kotah State	Crude opium from from Mangrol .	7·47	4·49	4·04	—
6,513	,, ,,	Cakes of opium from Mangrol .	8·23	5·69	4·56	—
6,507	,, ,,	Crude opium from Kishenganj .	40·32	14·00	12·04	13·79
6,514	,, ,,	Cakes of opium from Kishenganj	9·12	6·14	12·45	12·05
6,510	,, ,,	Crude opium from Ladpura . .	29·87	5·47	5·45	—
6,515	,, ,,	Cakes of opium from Ladpura .	7·33	5·68	6·23	—
6,516	,, ,,	Cakes of opium one year old .	7·84	6·34	9·60	—
6,517	,, ,,	Cake of opium ten years old .	6·52	12·62	10·55	—
	Average			7·55	7·69	—

It is seen that in each case the cakes of opium prepared by the native process yielded more morphine than the crude opium, but the differences are not very pronounced. The most noticeable feature of these results is the high percentage of morphine in the Kishenganj samples, and also in the cakes prepared in previous years, presumably without any special precautions. These figures afford confirmation of the statement that black soil is best for poppy cultivation in Kotah, for not only the Kishenganj samples, but also the Kotah samples from Bakani and Manoharthana (see p. 527) were grown on such soil.

Samples from Mewar, Rajputana

Second Series

The names of the varieties of poppy yielding these samples were not given, but the colours of the flowers were supplied.

No.	Flower.	Village.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4	Scarlet and white, plain variegated petals	Keshar Kheri	30·39	10·79	2·79	7·89	62·00
1	Plain white petals	Mungana	31·25	10·33	2·33	9·11	60·89
3	Pink and white, fringed variegated petals	,,	30·59	7·94	2·32	6·66	66·53
2	White fringed petals	Kapasin	29·15	7·06	2·70	8·66	63·77
5	Purple plain petals	Keshar Kheri	26·71	6·15	2·37	8·34	53·75
	Average			8·45	2·5	8·1	61·4

Samples Nos. 4 and 1 are good opiums, excepting that in the latter there is an excessive proportion of narcotine. Judged as a whole these samples do not compare favourably with the opiums from the Kotah State of Rajputana (p. 527) as regards the amounts of morphine and codeine present, whilst the narcotine occurs in larger quantity. Samples 4 and 1 are however quite suitable for medicinal use.

In the particulars supplied with these specimens, it is stated that the white flowering poppies produce the best opium. The analytical results do not supply conclusive evidence of this, although where the poppies were grown in the same village, as in the case of Nos. 1 and 3 and also Nos. 4 and 5, the figures favour this view.

First Series

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium.	
					Flückiger's method.	B.P. (1898) method.
			Per cent.	*Per cent*	*Per cent.*	*Per cent.*
6,159	Mewar	Fresh opium extracted from pure white poppies with fringed petals; dried to the necessary extent to ensure preservation in glass-stoppered bottle	30·15	10·74	10·89	12·55
6,160	,,	Opium juice collected from same field as 6,159 but prepared by the native process, then placed in glass-stoppered bottle	37·72	9·16	10·80	13·37

These two samples of opium, prepared from pure white poppies with fringed petals, are of very good quality. Sample No. 6,159 was collected without oil and dried with all its moisture, whilst the other was prepared by the native process, which involves the use of either poppy-seed or sesame-seed oil, much in the same manner as linseed oil is used in Malwa. The former sample yielded 12·55 and the latter 13·37 per cent. of morphine, so that in this case, as with the Kotah samples, the native process gave a slightly better opium.

Samples from Jaipur State, Rajputana

Second Series

The poppies grown in this State are distinguished according to the colour of the flowers.

No.	Flower.	District (Nizamat).	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
9	White flower of "Bhinda" seed . .	Malpura .	11·79	12·30	3·22	2·72	58·03
10	Rose-colour flower of "Hazaria" seed . .	,, .	11·43	11·11	3·08	3·95	58·66
5	"Blue" flower	,, .	13·37	8·85	2·68	6·55	59·17
8	,, ,,	,, .	11·31	8·80	3·04	4·47	61·42
2	,, ,,	Sawai, Jaipur	11·68	8·30	3·99	2·43	55·85
14	(Not given)	Dousa . .	20·98	8·30	2·89	3·39	48·39
4	White flower "Bhinda" seed . .	Malpura .	12·99	8·24	2 39	6·42	54·19
6	Rose-colour, "Hazaria" seed . .	,, .	15·37	7·87	2·46	9·26	55·89
7	Flowers of 3 varieties .	,, .	10·89	6·26	2·56	6·02	52·69
13*b*	(Not given)	Hindoun .	10·48	5·83	3·00	6·20	78·48
15	(Not given)	Dousa . .	28·80	4·68	3·78	6·06	53·01
3	Rose-colour, "Hazaria" seed . .	Sawai, Jaipur	13·58	4·59	3·53	8·26	58·52
1	White flower, "Bhinda" seed . .	,, ,,	10·61	4·34	3·40	7·56	60·06
13*a*	(Not given)	Hindoun .	8·40	4·26	3·47	5·89	47·28
	Average			7·4	3·1	5·6	57·26

Of these 14 samples Nos. 9 and 10 alone contain more than 10 per cent. of morphine; and these two samples are also satisfactory in yielding a large amount of codeine and a small proportion of narcotine. It is noticeable that the four best opiums are all from the same district, viz. Malpura, and that they include all the three varieties of poppy represented in this set of samples.

As a whole these opiums are not satisfactory, since only eight of the number contain sufficient morphine to justify their use for medicinal purposes. On the other hand the amount of codeine is high, and the percentage of narcotine is on the whole low. The percentage of aqueous extract is generally low, and indicates possible adulteration of the opium with insoluble substances. In the case of sample No. 13*b*, the percentage of matter soluble in water is abnormally high, and is possibly due to added soluble matter.

First Series

Source.	Description.	Narcotine on dried opium.	Morphine on dried opium. Flückiger's method.
		Per cent.	*Per cent.*
Jaipur .	Opium of the white-flowered . .	4·56	6·00
,, .	,, ,, "Soosni" . .	5·64	6·76
,, .	,, ,, pink (Gulabi) . .	6·47	5·71
,, .	,, ,, white and "Gulabi".	7·11	8·25
,, .	,, ,, red	7·12	8·81
	Average . . .	5·15	5·92

The morphine was determined by Flückiger's method, and the results are therefore about 1 per cent. lower than if determined by the British Pharmacopœia (1898) process. In making a comparison with the second series of samples from Jaipur, the average percentage of morphine in these five samples may therefore be taken as about 7 per cent., whereas in the 14 samples dealt with on page 530, the average is 7·4 per cent.

Samples from Bihar

Second Series

No.	Variety.	Village or district.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3	Bhaten and Katara seeds (vernacular name) . .	Dungsi .	23·02	8·62	3·29	8·9	66·03
4	Kitila or Kat-patta	Gangapur .	20·32	8·45	2·81	8·27	68·10
5	Dhaturia . .	Baithania Khurd	25·07	8·03	4·52	7·71	65·95
1	Bharuria . .	Nabigange .	25·82	7·5	3·96	7·57	64·94
2	Nativa . .	Nundpura .	26·94	6·23	2·88	6·54	63·01
6	Dhaturia . .	Barwat Sena	26·73	5·46	3·82	6·71	67·42
		Average . . .		7·4	3·5	7·6	65·9

These samples are poor in quality as regards morphine, but are exceptional in containing a large amount of codeine; sample No. 5 is particularly rich in codeine, and would be valuable as a source of this alkaloid.

The first four samples could be used for medicinal purposes, requiring an opium containing not less than 7·5 per cent. of morphine. The figures for narcotine are about the same as for morphine, and are somewhat excessive.

The distinct difference in the qualities of samples Nos. 5 and 6 is surprising when it is considered that both opiums were furnished by the same variety of poppy grown under very similar cultural conditions. In the notes supplied regarding the preparation of each specimen the only noticeable differences are (1) that the samples were produced in different villages by independent cultivators, and (2) that the crops preceding the sowing of the poppies were dissimilar, being rice in the case of No. 5, and Indian corn in the other case.

First Series

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium. Flückiger's method.
			Per cent.	*Per cent.*	*Per cent.*
6,260	Aliganj .	Opium with pasewa . .	6·56	6·20	6·66
6,261	,, .	Opium without pasewa. .	6·38	5·98	5·15
6,263	Shahabad (Dunraon)	Opium from white-stemmed poppy, dried with pasewa.	6·12	7·07	7·95
6,266	,,	Opium from white-stemmed poppy, without pasewa .	6·95	6·83	7·00
6,264	,,	Opium from black-stemmed poppy, dried with pasewa.	6·55	7·77	8·91
6,267	,,	Opium from black-stemmed poppy, without pasewa .	6·42	7·36	4·53
6,265	,,	Opium from Cajaria poppy, with pasewa . . .	7·82	7·06	7·15
6,268	,,	Opium from Cajaria poppy, without pasewa. . .	6·38	6·18	6·15
6,272	Bankipore	Crude opium dried with all its moisture as collected, neither rolled, nor manufactured, nor drained .	6·46	5·70	8·90
6,273	,,	Crude opium rolled in the hand at time of collection, otherwise dried with all its moisture . . .	14·78	8·48	8·76
6,274	,,	Opium prepared according to usual method . . .	14·50	8·78	7·72
		Average		7·04	7·17

The percentages of morphine in these specimens are much the same as in the samples of the second series dealt with in the preceding table. The samples contained between 4·53 and 8·9 per cent. of morphine, the average in the whole eleven samples being 7·17 per cent. The percentage of morphine in these samples is therefore low.

The analyses do not reveal any decided superiority among the specimens of opium derived from the different varieties of poppy in the Shahabad district.

Samples from Central India

Second Series

Samples of opium were received during 1909 from the following States in Central India: Jaora, Gwalior, Dewas Junior, Sailana, Piploda, Bagli, Indore, Rutlam, and Dewas Senior. For convenience the tabulated results of each State are given separately.

(1) *From Jaora State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1, 2	Dhaturia Sujed, Dhaturia Sosnia } mixed	27·43	11·15	2·56	10·25	59·28
30	Telia or Lilia	25·02	8·48	2·62	10·13	61·45
3, 4	Gulabi Lilia, Gulabi Paehrangi Lilia } mixed	29·52	8·16	2·40	10·55	63·92
29	Dhaturia	32·95	4·84	3·09	9·65	54·23
	Average		8·15	2·67	10·14	59·7

The last of these samples is the only one that could not be used medicinally, although in every case the amount of narcotine is excessive.

(2) *From Gwalior State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
10	Lilvo Lilya Surya	22·21	7·84	2·46	8·61	56·53
5, 6	Lal Dhaturia, Lilia } mixed	30·30	7·16	2·32	7·05	63·83
11	Dhalva Halya and Lilya Surya } mixed	28·02	7·14	2·20	7·76	55·69
7, 8	Dora Dhaturia, Doria } mixed	33·21	6·48	2·41	10·17	53·56
9	Kalia Agria	31·51	3·05	2·86	8·28	59·73
	Average		6·3	2·45	8·37	57·8

These five samples, especially No. 9, are inferior in quality owing to the low percentages of morphine and the relatively high proportions of narcotine.

(3) *From Dewas Junior State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
13*a*	Dhaula Agria	22·32	9·8	3·50	7·22	61·02
12*a*	Lilwa	22·57	8·67	3·21	7·94	61·32
13*b*	Dhaula Agria	20·96	8·57	2·94	7·49	59·30
14	Kala Ratlya	20·54	7·69	2·71	8·59	53·51
12*b*	Lilwa	22·31	5·90	3·58	7·97	60·59
	Average		8·1	3·2	7·8	59·1

The first three of these samples are moderately good as regards the percentage of morphine they contain, and all excepting the last could be used medicinally. The amount of narcotine present is fairly high.

The codeine figures show that these opiums are rich in this alkaloid.

(4) *From Sailana State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
18	Kathia . . .	26·17	12·63	2·52	7·58	60·13
17	Lilia . . .	24·24	9·75	2·97	6·87	59·74
16	Bhatpura . .	28·37	9·25	3·17	10·79	58·78
15	Dhaturia . .	28·49	9·05	2·38	9·69	53·98
19	Agria . . .	30·53	7·74	3·09	6·26	59·77
20	Dhaplia . .	29·30	7·69	3·59	7·54	57·09
	Average . . .		9·35	2·95	8·1	58·3

It will be seen that sample No. 18 gives a very satisfactory result as regards morphine and contains only a moderate amount of narcotine. The first four opiums contain an average of 10·17 per cent. of morphine and could be utilised for medicinal purposes requiring the 10 per cent. standard, while the last two of the samples both contain more morphine than is required by the lower (7½ per cent.) standard for opium.

(5) *From Piploda State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
22	Bhatphor . .	17·42	14·43	3·11	8·00	67·45
21	Dhaturia . .	19·95	10·34	2·91	6·43	64·86
23	Lilia . . .	19·73	9·48	3·21	9·02	61·93
	Average . . .		11·4	3·08	7·8	64·7

These samples, especially No. 22 (Bhatphor variety) are very satisfactory, as the percentages of morphine, codeine, and aqueous extract are all high, and the amount

of narcotine, excepting in the case of the Lilia variety, is relatively low.

These samples are as a whole the best of those from Central India, and are also exceptional in containing apparently less added oil.

According to the information supplied with these samples the Bhatphor and Dhaturia varieties yield 32 lb. of opium per acre in Piploda, whilst the Lilia variety only produces 22 to 26 lb. per acre. In Jaora the yield per acre of both these varieties is given as only 16 to 19 lb. It therefore appears that the yield from the Dhaturia poppy in Piploda is nearly twice that from Jaora; moreover, a comparison of the opiums produced in the two districts shows that the Piploda drug contains nearly twice as much morphine as that from Jaora. This illustrates the great differences that may occur when the same variety of poppy is grown in different districts.

(6) *From Bagli State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
28	Pyari	24·62	9·80	3·18	10·02	58·73
26	Gangdia	25·98	7·63	2·53	4·32	44·95
27	Telia	25·19	5·83	4·04	7·49	56·89
25	Kalia	24·39	5·80	2·71	9·23	52·29
24	Gankania	31·34	4·49	3·80	5·45	73·45
	Average		6·7	3·25	7·5	57·3

Sample No. 28 is of good quality as regards morphine and codeine but contains a large amount of narcotine. In sample No. 26 the relative proportion of the different alkaloids is satisfactory, but owing to the high percentage of insoluble matter present, probably due to adulteration, the opium actually contains only a moderate percentage of morphine.

The remaining samples are poor in quality as regards morphine but contain a large percentage of codeine; this is especially the case with No. 27.

(7) *From Indore State*

No.	Variety.	District.	Moisture.	Calculated on dried opium.			
				Morphine.	Codeine.	Narcotine.	Aqueous extract.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
40	Dublio . .	Gorot . .	15·03	13·92	3·50	6·42	69·52
34	Saphet Katria or Suphet Katriya	Rampoora .	16·82	11·55	2·48	7·74	66·8
35	Telia . . .	,,	22·53	11·25	2·99	8·87	62·44
31	Bhatphodia .	,,	23·05	9·76	2·94	9·29	62·43
33	Gingoria or Gingodia . .	,,	22·22	9·73	3·55	9·15	57·85
39	Dhaturia . .	Gorot . .	17·94	8·76	3·05	5·96	65·44
32	,, . .	Rampoora .	26·36	8·19	3·02	10·14	61·73
38	Sufed Dhaturia .	Gorot . .	19·62	7·89	3·20	9·51	61·15
37	Lakdaya . .	,, . .	16·82	6·93	3·97	7·53	65·49
36	Safed Phul . .	,, . .	28·47	5·20	3·22	6·57	51·72
	Average			9·3	3·2	8·1	62·4

The average figures for these ten samples are very satisfactory, especially as regards morphine, if the last two are excluded. The eight remaining samples contain an average of 10·13 per cent. of morphine, and would be valuable for medicinal purposes. Sample No. 40 (Dublio variety) is of particularly good quality, as it contains high percentages of morphine, codeine, and extractive matter, and also a low proportion of narcotine. The high percentages of codeine and soluble matter are noticeable features in these samples.

Some of the specimens, especially Nos. 36 and 38, were contaminated with added oil, and it will be seen that these opiums are of inferior quality, especially as regards the amount of morphine they contain.

Of these ten samples from Indore State, five (Nos. 31 to 35) were produced in the district of Rampoora, and the remaining five in Gorot district. With the exception of three (Nos. 31 to 33) all were from different villages. A comparison of the produce of the two districts is interesting. The average percentage of morphine in the Rampoora samples is 10·1, the variation being from 11·55 to 8·19, whilst in the specimens from Gorot the amount varies from 13·92 to 5·2, the average in this case being 8·5 per cent. Although, therefore, the best individual specimen was from Gorot, the Rampoora samples were on the whole distinctly better in quality.

There is no appreciable difference in the two "Dhaturia" specimens from the two districts.

(8) *From Rutlam State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
44 45	Dhaturia, No. 1, white flowers, unfringed petals Dhaturia, No. 2, pink and white flowers, fringed petals } mixed	26·36	10·2	2·76	9·16	60·32
41	Lakdia	24·86	9·61	2·67	8·58	57·45
46	Bhatpada or Mandhari . .	27·43	8·23	2·71	10·61	57·14
48	Kala Agrya	24·62	8·23	2·68	11·23	56·24
47	Dhaplia	27·82	7·42	3·83	9·17	53·19
43	Agria	24·06	6·97	2·83	9·81	59·82
42	Lilia or Sudia . . .	25·40	6·44	3·27	9·42	59·40
	Average		8·16	2·95	9·7	57·65

Taken as a whole these samples are not very satisfactory as regards morphine, and they have the disadvantage of containing a high proportion of narcotine; on the other hand the codeine figures are good, especially in the case of sample No. 47 (Dhaplia variety). With the exception of the first sample—the best in this consignment—these opiums were very oily, and it is probably partly owing to this fact that the quality is not more satisfactory.

(9) *From Dewas Senior State*

No.	Variety.	Moisture.	Calculated on dried opium.			
			Morphine.	Codeine.	Narcotine.	Aqueous extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
57	Lakdya . .	21·41	12·61	2·52	11·22	61·53
53	Gangdya . .	10·46	11·84	2·87	6·78	65·61
54	Sudya . . .	13·74	8·84	2·96	8·11	59·81
52	Dhaturya . .	10·31	7·96	3·01	8·62	57·57
49	Agrya . . .	23·39	7·12	3·50	10·00	55·94
56	Ghotia. . .	18·98	6·91	3·67	8·08	63·65
51	Lilwa . . .	16·19	6·86	2·92	8·27	62·77
58	Jagannathya .	25·60	5·94	3·21	7·62	59·27
55	Nakumdi . .	20·25	5·57	2·87	8·82	56·28
50	Kasturiya . .	18·09	5·03	3·06	7·98	55·17
	Average . . .		7·86	3·06	8·55	59·76

Sample No. 57 is very satisfactory as regards morphine, but has the disadvantage of containing a large amount of narcotine. Sample No. 53, although containing a little less morphine than the last, is more satisfactory, for it contains more codeine and extractive matter and considerably less narcotine. The remaining samples are deficient in morphine but fairly rich in codeine.

Samples No. 49, 55, 56, and 58 were perceptibly oily, and in all these cases the percentage of morphine is low.

A comparison of the quality and yield of some of these samples is shown in the following table:

Variety of poppy.	Morphine in opium. *Per cent.*	Yield of opium per acre.
Lakdya	12·61	13 to 16 lb.
Gangdya	11·84	13 lb.
Sudya	8·84	22 lb.
Dhaturya. . . .	7·96	19 to 22 lb.
Lilwa	6·86	19 lb.

Judging from these figures, opiums of the best quality from this State are not so satisfactory as regards yield.

First Series (Central India)

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium. Flückiger's method.	Morphine on dried opium. B.P.(1898) method.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
6,017	Bhopal	Crude opium collected without oil in porous vessels and drained .	44·27	9·69	5·34	—
6,018	,,	Crude opium collected without oil in glazed vessels and undrained .	45·25	9·69	8·86	—
6,019	,,	Crude opium collected with oil in glazed vessels and undrained . .	Oily	9·24	6·94	—
6,020	,,	Crude opium collected with oil and soused with oil, ordinary Malwa fashion	Oily	5·06	5·10	—
6,229	,,	Two balls of opium, one year old . . .	10·93	7·34	6·64	—
		Average		8·20	6·58	—
6,021	Ujjein	Same as 6,017 . . .	21·36	8·21	11·71	13·45
6,022	,,	Same as 6,018 . . .	25·13	11·02	11·43	13·37
6,023	,,	Same as 6,019 . . .	Oily	20·71	2·42	—
6,024	,,	Same as 6,020 . . .	,,	15·86	5·15	—
6,228	,,	Two balls of opium, one year old. . . .	8·99	6·57	7·32	—
		Average		12·47	7·61	—

No.	Source.	Description.	Moisture.	Narcotine on dried opium.	Morphine on dried opium.	
					Flückiger's method.	B.P. (1898) method.
			Per cent.	Per cent.	Per cent.	Per cent.
6,025	Indore	Same as 6,017 . . .	23·12	11·81	6·22	—
6,026	,,	Same as 6,018 . . .	21·94	11·52	4·94	—
6,027	,,	Same as 6,019 . . .	Oily	10·57	5·52	—
6,028	,,	Same as 6,020 . . .	,,	12·58	3·57	—
6,227	,,	Two balls of opium, one year old . . .	9·27	7·39	8·35	—
6,233	,,	Opium biscuits in trash .	6·91	6·34	7·54	—
Average				10·03	6·02	—

The average percentages of morphine in these samples are rather low. It is of interest, however, that in each series the highest percentage of morphine was furnished by one of the specimens collected without oil. The two specimens from Ujjein which were collected without oil each contained over 13 per cent. of morphine as determined by the British Pharmacopœia (1898) method.

General Remarks on the Samples from Central India

The samples of the second series sent from this Province numbered altogether 55, *i.e.* rather more than one-half the total number of samples received at the Imperial Institute from India in 1909. They were from nine different States, all of which are within the Malwa portion of Central India. Ten of these samples, *i.e.* 18 per cent. of them, contained amounts of morphine varying from 10·2 to 14·4 per cent., the average being 12 per cent. The three States which furnished the best opiums were, in order of importance, Piploda, Indore, and Sailana, the average percentage of morphine in the nineteen samples from these States being as high as 9·7 per cent., an amount which would justify the use of the whole of these samples, if mixed in equal quantities, for medicinal purposes requiring opium that contains not less than 9·5 per cent. of morphine when dry.

From these results it is evident that it is possible to obtain opium from these Malwa States quite comparable in composition with the Turkish drug which is at present

chiefly used in Europe for medicinal preparations; but the quality of a large number of the samples could no doubt be improved.

The practice in vogue throughout Central India of adding linseed oil to the crude opium, both at the time of collection and in storing it, would have to be abandoned in preparing opium for medicinal use, as the presence of oil would be a great disadvantage. It was noticeable during the present investigation that almost without exception the opiums containing an appreciable amount of oil were inferior in quality, especially as regards the yield of morphine, whilst on the other hand the best opiums were, as a rule, those least contaminated with oil.

This conclusion is in agreement with what has already been said on pages 519-521, where the results of analyses are given of opiums from the Central India States, Bhopal, Ujjein, and Indore. These samples were treated in both the Bengal and Malwa fashions, so as to afford evidence of the influence of adding oil as is customary in the latter region.

Varieties of Poppy

The opiums of the second series were mostly distinguished by native names signifying the particular variety of poppy from which they were derived, and in some cases the samples from different districts bore the same name. A comparison of these similarly named opiums shows a great variation in their quality, as seen in the following table, but the differences may be chiefly due not to the plants, but to the different methods of treatment as practised in the several centres of cultivation.

Table indicating the Variation in Composition of Opium from similarly named Varieties of Poppy

Variety of poppy.	No. of samples.	Morphine.			Remarks.
		Highest.	Lowest.	Average.	
		Per cent.	*Per cent.*	*Per cent.*	
Dhaturia . .	9	10·35	4·85	8·1	Seven of these samples were from six different States in Central India, and two were from Bihar.
Agria or Agrya	3	7·7	7·0	7·3	All from different States in Central India.
Dhaula Agria .	2	9·8	8·57	9·2	From the same State (Dewas Junior).
Lilia[1] . .	3	9·75	6·44	8·6	From different States in Central India.
Telia[1] . .	3	11·25	5·83	8·5	From different States in Central India.
Gotia or Ghotia	4	14·52	6·91	9·8	Three of these samples were from Kotah State; the other (the lowest) from Central India.
Lakdya, Lakdia, or Lakdaya .	3	12·61	6·93	6·4	From different States in Central India.
Bhinda . .	3	12·3	4·34	8·3	From the same State (Jaipur).
Lilwa . .	3	8·67	5·9	7·1	All from Dewas Junior State, Central India.

[1] *These varieties are probably identical.*

The Dhaturia variety is that most commonly represented in the samples; the analyses of the opiums do not, however, justify a preference for it, although they show that, in certain cases, a large percentage of morphine is present. The results obtained from the Dhaula Agria, Lilia and Telia varieties, although not good as a whole, show that a satisfactory opium is sometimes furnished by these varieties.

In the case of Gotia, Lakdya, and Bhinda, a great variation in the morphine figures is noticeable, but it is evident that these varieties are capable of yielding opiums exceptionally rich in morphine.

The varieties yielding the best opiums are shown in the following table, which comprises all those samples which contained 11 per cent. or more of morphine;

Number according to quality.	Variety.	Morphine in dried opium.	Geographical source.
		Per cent.	
1	Gotia . . .	14·52	Kotah State, Rajputana.
2	Bhatphor . .	14·43	Piploda State, Central India.
3	Dublio . . .	13·92	Indore State, Central India.
4[1]	(Unknown) . .	13·63	Shahpur, Punjab.
5	Nakumri . .	13·18	Kotah State, Rajputana.
6	Kathia . . .	12·63	Sailana State, Central India.
7	Lakdya . . .	12·61	Dewas Senior State, Central India.
8	Bhinda . . .	12·30	Jaipur State, Rajputana.
9	Katra . . .	11·85	Kotah State, Rajputana.
10	Gangdya . .	11·84	Dewas Senior State, Central India.
11	Saphet Katria .	11·55	Indore State, Central India.
12	Telia . . .	11·25	,, ,, ,, ,,
13	Harera . . .	11·22	Bara-Banki, Oudh.
14	Dhaturia Sujed and Dhaturia Sosnia	11·15	Jaora State, Central India.
15	Hazaria . .	11·11	Jaipur, Rajputana.
16	Tenia . . .	11·0	Bara-Banki, Oudh.

[1] *There is some doubt as to whether this is a true opium or an opium extract* (*see p.* 524).

The average percentage of morphine in these 16 samples is 12·4 per cent.

It is noticeable that in all these 16 samples, with the possible exception of Nos. 6 and 9, the varieties are dissimilar. It is impossible to conclude to what extent the variety of poppy determines the quality of these samples, for, as already mentioned, the local conditions as to climate, soil, and methods used, also the care and skill exercised by the cultivator, most probably have an even greater influence on the quality than the variety of poppy grown. If the two samples from Oudh (Nos. 13 and 16) and the doubtful sample No. 4 are excluded, all the remaining 13 samples are either from Rajputana or Central India (Malwa Division). The "Gotia" variety is especially to be recommended not only on account of yielding the best opium, but also owing to the larger yield of opium said to be obtainable from it as compared with the varieties grown in the Kotah State.

As already mentioned these results leave no room for doubt that it is possible to obtain Indian opium suitable for medicinal purposes, yet it is evident that much could be done to improve the opiums generally. It was pointed out that it is important that experiments should be made

with the 16 varieties already indicated in order to determine the variety of poppy best suited to the local conditions and giving the highest quality and yield of opium.

It was thought possible that the botanical specimens of poppy plants corresponding to the opium samples might be classified into botanical varieties, and that the variations in the quality of the opiums might thus in some measure be accounted for.

With this object in view the plants were sent to the Royal Botanic Gardens, Kew, where they were examined and found to belong to *Papaver somniferum*, Linn. Attempts were made to divide the specimens into mutually exclusive groups, but without success, and it was stated that a satisfactory classification of the various forms could only be accomplished in the field by a careful observer and judicious cultivator. It would therefore appear that the various forms represent the result of many years of cultivation and hybridisation of closely allied forms or geographical races of *Papaver somniferum*, and that experimental cultivation alone can lead to a satisfactory classification.

In this connexion it is interesting to note that Mr. and Mrs. Howard and Mr. A. R. Khan (*Memoirs of the Department of Agriculture, India*, 1910, **3**, 323) conclude from trials made at Pusa that the opium poppies at present cultivated in India are often largely composed of hybrids, except perhaps in the United Provinces.

Conclusions and Recommendations

The results of this investigation clearly show that it is possible to obtain Indian opium with a sufficiently high percentage of morphine for it to be used for medicinal purposes in Europe. The following table summarises the percentages of morphine in the second series of samples dealt with in the present report:

Morphine contained in the dried opium.	No. of samples.
14 to 15 per cent.	2
13 " 14 " "	3
12 " 13 " "	3
11 " 12 " "	8
10 " 11 " "	5
9 " 10 " "	14
8 " 9 " "	24
7 " 8 " "	16
6 " 7 " "	9
5 " 6 " "	11
4 " 5 " "	6
3 " 4 " "	1
Total number of samples	102

The average amount of morphine in 50 per cent. of the samples was as much as 10·26 per cent., consequently one-half of the samples from the various opium districts of India could be utilised as medicinal opium containing 10 per cent. of morphine. A further 20 per cent. of the samples contained 7·5 per cent. or more of morphine and could be used medicinally for the purposes restricted to opium containing this minimum amount of morphine. There were thus only 30 per cent. of the samples which contained insufficient morphine to justify their use for medicinal purposes in the United Kingdom.

The amount of codeine in the whole of these samples varied from 2·18 to 4·04 per cent., the average being exactly 3 per cent.

There can be little doubt from the composition of Indian opium that samples containing the required percentage of morphine could be satisfactorily employed in European medicine. Preliminary trials of Indian opium in medicine have confirmed this conclusion. Experiments have been made at the Imperial Institute which show that Indian opium could be satisfactorily employed as a source of morphine or of codeine, and as stated on p. 507 Indian opium is now being used in the United Kingdom for the preparation of these alkaloids.

Improvement of Quality

It has already been pointed out that the addition of linseed or other oil to the crude drug, both at the time of

its collection and during storage, would have to be discontinued if the opium were to be exported for medicinal use. In the production of Turkish opium in Asia Minor it is the practice, when scraping the crude drug from the capsule, to wet the knife with saliva by drawing it through the mouth so as to prevent the adhesion of the juice to the blade. This practice is not to be recommended, but it indicates that the use of oil is not essential, and that possibly dipping the knife in water would be as satisfactory.

The dried stamens which occur on the poppy capsules are another source of contamination, for unless these are removed before the capsules are lanced they become detached and mixed with the drug when the latter is scraped from the capsule.

The different methods employed in India and Asia Minor for lancing the capsules suggest the possibility of improvement in this respect. In India the incisions are made vertically, usually with a three-bladed instrument, and each capsule is lanced three or four times at intervals of two to four days; whereas in Asia Minor the incision is made transversely about half-way up the capsule and extends about two-thirds round the circumference, or is carried spirally to beyond its starting-point; and each capsule is as a rule cut only once. By the latter method there is certainly a great saving in time, as not only do the heads receive only one lancing, but also the scraping of the drug from the capsule is completed in one operation. It is in the lancing of the poppy heads and in the collection of the drug that the question of labour becomes particularly important, and as the time for these operations is very limited they require a good supply of labour. In Asia Minor the poppy is generally sown at three different times in the one season, as by this arrangement not only is the chance of a total failure of the crops minimised, but there is a difference of a fortnight between the time at which the first and last sowings arrive at maturity, and this economises labour in the collection of the opium. It is evident that if it is decided to export opium from India for medicinal use in Europe, much could be learned from a study of opium production in Turkey.

TOBACCO FROM CYPRUS

In former times the tobacco-growing industry in Cyprus was of some importance, but in late years it has practically disappeared. In 1905, after visiting Cyprus at the request of the Secretary of State for the Colonies, Prof. Wyndham R. Dunstan, F.R.S., the Director of the Imperial Institute, suggested that the re-establishment of the tobacco-growing industry might prove of profit to the island and should therefore receive attention from the Agricultural Department (*Report on the Agricultural Resources of Cyprus* [Cd. 2717] 1905). In 1913, a company was formed with the object of reviving the industry, and the plant is now being cultivated at a number of villages in the island, mostly in the Limassol district. The crop is also being grown experimentally by the Department of Agriculture, and in June 1915 five samples of locally grown Turkish tobacco, produced from imported seed, were received for examination. Only two of these, Nos. 1 and 2, were sufficiently large for complete examination, *i.e.* chemical analysis, technical trial, and valuation.

The description of the samples, together with the results of the examination of Nos. 1 and 2, are given below.

No. 1. "*Grown at Nicosia, good quality.*"—The sample consisted of a number of hands, each containing from 14 to 25 leaves, measuring from 3 × 1½ in. to 8 × 3½ in. The leaves were rather uneven in colour but were generally of a dull yellowish-brown and were similar in appearance to Turkish leaf of the Basma type. A number of the leaves had dark or greenish patches round the midrib. They were rather damp but free from mould, though some of them had a slightly mouldy odour.

The aroma of the leaves was good but faint.

The tobacco burned well in cigarette form with a pleasant but rather weak aroma, leaving a greyish-black ash. The smoke was rather pungent but of good though mild aroma.

The tobacco was analysed with the following results:

	Per cent.
Moisture	15·0
Nicotine	0·80
Nitrogen	1·47
Ash	13·50

The ash contained:

Lime	CaO	28·99
Magnesia	MgO	7·62
Potash	K_2O	16·17
Soda	Na_2O	2·05
Sulphates, expressed as sulphuric acid	SO_3	4·21
Chlorides, expressed as chlorine	Cl	6·18

The percentages of nitrogen and nicotine are satisfactorily low. The ash contains rather more of the deleterious constituents, sulphates and chlorides, than is desirable, but it is not on the whole inferior to that of some Turkish varieties.

No. 2. "*Grown at Nicosia, medium quality.*"—This sample was similar to the preceding sample, but the colour was on the whole rather brighter and more like that of typical Turkish tobacco. The leaves measured from 2½ × 1½ in. to 6 × 2½ in., and were of a dull yellowish-brown colour with occasional dark brown or green patches.

The tobacco burned well in cigarette form, yielding a smoke which was rather bitter, but of good though mild aroma. The ash was greyish with patches of black.

The tobacco was analysed with the following results:

	Per cent.
Moisture	14·8
Nicotine	0·90
Nitrogen	1·44
Ash	13·05

The ash contained:

Lime	CaO	31·25
Magnesia	MgO	8·13
Potash	K_2O	17·59
Soda	Na_2O	3·81
Sulphates, expressed as sulphuric acid	SO_3	4·57
Chlorides, expressed as chlorine	Cl	6·36

The composition is practically identical with that of the first sample.

No. 3. "*Grown at Polis tes Khrysokhou.*"—The sample consisted of 6 hands of leaves, somewhat similar to samples Nos. 1 and 2 in appearance, but rather stouter and measuring 3 × 1½ in. to 5 × 2 in. A number of the leaves were rather torn.

No. 4. "*Grown at Morphou Nursery Garden.*"—The

sample consisted of 2 hands of leaves, which were rather larger than those of the other samples and badly torn. They were somewhat thin, smooth in texture, and lacked strength. The leaves measured from 6 × 2½ in. to 10 × 6 in., and were of a very uneven, dull, pale brown colour with greenish-brown patches.

No. 5. "*Grown at Lapithos Nursery Garden.*"—The sample consisted of five hands of leaves similar in appearance to No. 4, and varying in size from 4½ × 1½ in. to 8½ × 4½ in. The largest leaves were rather badly torn.

The samples were submitted for valuation to three firms of manufacturers.

(*a*) One firm reported that these Cyprus tobaccos were all of good burning quality and possessed the characteristic flavour of Turkish tobacco. They were of opinion that such tobaccos would be quite saleable in the English market for the purpose of blending with the fuller flavoured Turkish varieties. They considered No. 2, "Nicosia," medium quality, to be the best of the five samples, and No. 4, "Morphou," the poorest in quality. They valued them in London as follows:

	Per lb.		Per lb.
No. 1	1*s*. 2*d*.	No. 4	6*d*.
" 2	1*s*. 6*d*.	" 5	9*d*.
" 3	8*d*.		

(*b*) A second firm, who specialise in cigarettes, reported that the tobacco was of the Basma type. Samples Nos. 1, 2, and 3 were the best, and might be placed in one category, with Nos. 4 and 5 in another. They were of opinion, however, that such tobaccos would only be suitable for blending purposes and could not be used by themselves. They considered that the best qualities might realise from 1*s*. 6*d*. to 2*s*. per lb., but that Nos. 4 and 5 would only be worth 4*d*. to 6*d*. per lb.

(*c*) Samples of Nos. 1 and 2 were also submitted to a third firm to be made into cigarettes for experimental purposes. In returning the cigarettes the firm pointed out that the tobaccos were not fully matured and that it was therefore not a fair test to smoke them in this condition, as the quality and aroma would be greatly enhanced

when the tobacco had matured by proper storage. They stated that at this time of year (July) all tobaccos are more or less in a "sick" condition, due to the heat and humidity, and that it would be fairer to test the cigarettes in three months' time. The two samples were of very satisfactory appearance, but in their present condition were lacking in aroma. The firm added that they considered these tobaccos would be very suitable for the English market, if in the condition indicated, and valued them at the present time (July 1915) at from 1*s.* 6*d.* to 2*s.* per lb., or under normal conditions at from 1*s.* to 1*s.* 3*d.* per lb.

It has been stated already that only samples Nos. 1 and 2 were large enough for complete examination, and the following remarks are based on the results given by these two samples.

Samples Nos. 1 and 2 conform with Turkish tobacco as regards size of leaf, but they contain too much moisture for the English market. The moisture should not exceed from 10 to 12 per cent., as no allowance is made for excess of moisture when duty is paid on withdrawal of the tobacco from bond. The excess of moisture has also caused a rapid secondary fermentation in this tobacco, to which are due the dark patches round the midrib referred to in the descriptions. The tobacco smokes rather "hot" and is only mildly aromatic, but these defects will probably disappear with more experience in the curing of the tobacco. The object should be to produce tobacco resembling as closely as possible tobacco of the Turkish Basma type.

It was pointed out that it would be advisable to try a number of types of Levantine tobacco with a view to the selection of those best suited to the district.

COPRA FROM QUEENSLAND

The cultivation of the coconut in Queensland was at one time confined to a few islands of the Torres Straits but is now rapidly extending southwards. The total area under the palm in 1913 was 549 acres as compared with 365 acres

in 1912. Copra first appeared in the agricultural statistics in the latter year, when the production of 31 tons was recorded.

It has been stated that there is a general opinion that coconuts grown in Queensland do not contain sufficient oil to be of commercial value, and in order to test the point a sample of copra was forwarded to the Imperial Institute for examination in July of this year.

The sample, which was produced at the Kamerunga State Nursery, Cairns, North Queensland, consisted of clean, well-prepared copra from fair-sized nuts and was in good condition, only a few of the pieces being slightly discoloured.

The copra contained 4·4 per cent. of moisture and yielded 64·6 per cent. of oil, equivalent to 67·6 per cent. on the dry copra. The oil possessed the usual characters of coconut oil and was of good quality, the acidity being very low.

The yield of oil from this sample of Queensland copra is quite equal to that furnished by other varieties of commercial copra. Kiln-dried copra is stated to yield from 63 to 65 per cent. of fat, whilst copra dried in hot air gives a higher yield which sometimes reaches as much as 74 per cent. There is no doubt that copra containing 67·6 per cent. of oil in the dry material would meet with a ready sale if placed on the market in good condition.

The sample was submitted for valuation to a firm of oil-seed crushers, who treat copra, and also to brokers. The oil-seed crushers reported that the copra was of very fair quality, but they pointed out that it would be desirable to reduce the amount of moisture from 4·4 per cent. to about 3 per cent. They stated that the excess of moisture makes a considerable difference in the value of the copra for crushing purposes, as it renders the material more difficult to grind and consequently reduces the yield of oil obtained on pressing. They valued the sample at about £25 per ton c.i.f. London (October 11, 1915) and stated that a little extra drying and if necessary the breaking of the copra into rather smaller pieces would increase its value by about 10*s*. per ton.

The brokers described the sample as sun-dried copra of good colour and valued it at £24 15*s.* per ton c.i.f. London (October 6, 1915).

For comparison with these valuations, quotations for the chief commercial varieties of copra in London, on approximately the same dates, are given below:

Nominal Quotations for Current Shipments of Copra to London

		October 6, 1915. Per ton.	October 13, 1915. Per ton.
		£ s. d.	£ s. d.
Malabar	Bags	26 0 0	26 15 0
Ceylon	,,	25 0 0	26 0 0
Java	,,	25 0 0	26 5 0
Singapore	,,	24 2 6	24 12 6
Straits	,,	23 17 6	24 10 0
Mozambique	,,	23 5 0	24 5 0
Manila	Bulk	23 0 0	23 12 6
Cebu	Bags	23 7 6	24 0 0
Macassar, etc.	,,	23 12 6	25 0 0
Zanzibar	,,	24 5 0	24 15 0
South Sea	,,	22 15 0	23 12 6

The results of this investigation show that the Queensland copra contains a normal amount of oil and that commercial shipments would be readily saleable in London at good prices, especially if care were taken to dry the copra so that it contains not more than 3 per cent. of moisture.

Until recently the bulk of the copra shipped to Europe was crushed in France and Germany. On the outbreak of war, British producers of copra in Ceylon, India, and elsewhere were placed in a serious position, owing to the fact that their produce had hitherto been marketed in Germany and that the war had closed that market. In order to overcome this difficulty the Imperial Institute issued a special circular to British oil-seed crushers calling their attention to the importance of the copra-crushing industry. As a result, a number of British firms have started the crushing of copra and there is now a good market for copra in this country.

COCOA FROM NIGERIA

In a previous number of this Bulletin (1914, **12**, 213) an account was given of the results of examination of samples of cocoa prepared in various ways in the Southern Provinces of Nigeria. In April 1915 two further specimens were received; they had been prepared from a single sample of fermented beans by dividing it into two parts and drying one by means of a rotary drier and the other in the sun.

No. 1. *Dried in rotary drier.*—This sample consisted of beans of small to medium size, in good condition, with a pleasant and fairly full flavour. The husk was brittle, but in most cases unbroken, and of an uneven dull brown colour. The "break" was fairly easy, showing a good colour.

No. 2. *Sun-dried.*—This was similar to No. 1, but the beans were rather plumper and had a somewhat easier "break." The husk was mostly of a light reddish-brown tint, with darker patches.

The size, weight, etc. of the beans as received at the Imperial Institute were as follows:

	No. 1. Machine-dried.	No. 2. Sun-dried.
Relative size, i.e. number of beans required to fill a cylinder 5·3 cm. in diameter and 9·3 cm. in height	101	92
Average weight of a single bean, in grams	1·11	1·16
Percentage of husk in beans	11·8	12·6

The beans, after removal of the husks, were analysed with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*
Moisture	5·2	5·2
Ash	2·8	2·7
Fat	50·5	51·2
Total alkaloid	2·05	1·92

The composition of the beans is quite satisfactory, but it is of interest to note that the percentage of total alkaloid is a little above the normal in both samples. Previous samples of fermented cocoa from Nigeria examined at the Imperial Institute were found to contain 1·58 to 1·80 per cent. of alkaloid, and unfermented cocoas from 1·87 to 1·92 per cent.

The samples were submitted to brokers and to cocoa and chocolate manufacturers, who all expressed very favourable opinions as to the quality of both products, but considered No. 2 to be slightly superior.

The samples were valued as follows:

No. 1, from 76*s.* to 78*s.* per cwt.,

No. 2, from 77*s.* to 79*s.* per cwt.,

with St. Thomé and Cameroons cocoas at about 74*s.* to 77*s.* 6*d.* per cwt. (July 1915).

The present report confirms the observations recorded in the earlier report (*loc. cit.*), that there is little to choose between the value of sun-dried and artificially dried cocoas, provided the drying is carefully conducted in both cases and the cocoa is well fermented and of good quality to start with. The results of the present and previous investigations may be summarised as follows:

	Method of preparation.	Condition of sample as received at the Imperial Institute.	Valuation per cwt.
First Series (this BULLETIN, 1914, **12**, 213)	1. Fermented; artificially dried for 15 hours in rotary drier.	Over-dried; husk often cracked or broken away; fracture sometimes slaty.	57*s.*[1]
	2. Fermented; dried in sun 2 hours and then artificially for 14 hours in rotary drier.	Husk brittle, but usually unbroken and showing white bloom; fracture often purplish.	54*s.* 6*d.* to 55*s.* 6*d.*[1]
	3. Fermented, sun-dried for 3 hours and then artificially dried for 9 hours in rotary drier.	Similar to No. 2, but fracture less frequently slaty.	61*s.*[1]
	4. Fermented and sun-dried.	Husk unbroken; fracture similar to No. 3.	60*s.*[1]
	5. Prepared in native fashion.	Beans mostly rather shrivelled; fracture slaty.	56*s.*[1]
Second Series, dealt with in present report.	1. Fermented; artificially dried.	Husk brittle, but mostly unbroken; fracture easy and of good colour.	76*s.* to 78*s.*[2]
	2. Fermented; sun-dried.	Similar to No 1, but rather plumper, and break rather easier.	77*s.* to 79*s.*

[1] *On the same date St. Thomé and Cameroons cocoas were quoted at* 59*s. to* 62*s. per cwt.*

[2] *On the same date St. Thomé and Cameroons cocoas were quoted at* 74*s. to* 77*s.* 6*d. per cwt.*

PIASSAVA INDUSTRY OF BRITISH WEST AFRICA

WEST AFRICAN piassava is a brush-making fibre obtained from the leaf-sheaths of the wine-palm (*Raphia vinifera*). It is produced in most of the British West African possessions, but chiefly in Sierra Leone.

The exports of piassava from Sierra Leone in 1914 were 983 tons, value £19,492, as compared with 839 tons, value £12,280, in 1913. The increase in the quantity of fibre shipped was due to the exceptionally high prices quoted in the home market, the average price during 1913 being £23 a ton, whilst in December 1914 £59 a ton was offered, notwithstanding the closing of the German market on the outbreak of war. In 1914, 546 tons were shipped to the United Kingdom and 437 tons to Germany, as against 302 tons to the United Kingdom and 537 tons to Germany in 1913. The whole of the increase in 1914 occurred during the war period. The increase in the value of piassava in the English market was due on the one hand to a decline in the supply owing to lack of freights after the outbreak of war, and on the other hand to an increased demand for brooms for the Army and the transfer of American custom from the German to the English market.

In 1914, 403 tons of piassava, valued at £5,117, were exported from Nigeria, as compared with 228 tons, of value £2,806, in 1913. In both years practically the whole of the material was shipped to the United Kingdom. No exports of the fibre from Gambia or the Gold Coast have been recorded in recent years.

According to a report communicated some time ago by the Colonial Secretary, Gambia, to the West African Section of the Liverpool Chamber of Commerce, the piassava industry in Gambia appears to be worthy of attention with a view to development. The palm grows on the banks of the river, which is navigated by ocean-going vessels. Many years ago a company worked this fibre and put up a factory at Sukutu wharf, in the MacCarthy Island Province, equipped with the necessary machinery and a Decauville rail to bring the fibre from the swamp to the

factory. The undertaking failed, it is stated, through faulty management and lack of capital—contingencies which could be provided against in any future attempt. The difficulty of getting labour, which is scarce in Gambia, would not affect this undertaking, because with machinery on the spot to prepare the fibre only a few hands would be required to cut the growth and a few more to run the machinery.

In the course of preparing piassava in Sierra Leone, a fibrous by-product is obtained which hitherto has not been utilised. In order to ascertain whether this material has any commercial value, a sample was forwarded recently to the Imperial Institute for examination.

It consisted of a matted mass of reddish-brown fibre, resembling coir in appearance. The material was fairly clean, but contained a small quantity of hard black cuticle. The fibres were irregular, some being fine and hair-like and others coarse and woody.

The material was very irregular in strength, and varied in length from 1 to 3 ft., but was mostly from about 20 to 30 in.

The fibre was examined chemically with the following results:

	Per cent.
Moisture	9·0
Ash	3·4
Cellulose	65·8

The most likely use of this material appeared to be as a substitute for low-grade coir, and the sample was therefore submitted to coir merchants for their opinion. Their report indicated that the material would be accepted on the market as a coir substitute, and that, so far as could be judged from the small quantity available, it would realise about £6 to £8 per ton in London, if shipped in good dry condition in press-packed bales (March 1915).

In order to obtain an accurate idea of its value, it was suggested to the Sierra Leone authorities that a trial consignment of about 2 tons should be sent to London for sale. Should it be found profitable to export the material at the price quoted, the piassava trade is likely to be permanently benefited.

ASBESTOS FROM SOUTH AFRICA

A SMALL consignment of blue asbestos from South Africa was received at the Imperial Institute in April 1915 in order that samples might be submitted for valuation to a number of firms in the United Kingdom. Although blue asbestos has been exported from South Africa, comparatively little use has been made of it in this country.

The consignment consisted of two portions:

(*a*) A bag containing a few pounds of crocidolite asbestos, free from rock impurity, clean, and of good colour. The fibres were tough, and varied in length up to 1½ in. Such asbestos would be suitable for textile purposes.

(*b*) The bulk of the consignment consisted of crocidolite asbestos mixed with a considerable amount of rock impurity, and included many lumps of unteased fibre. The teased portion of this asbestos was on the whole duller and of poorer colour than the smaller portion (*a*), presumably owing to the presence of rock dust, but otherwise it did not appear to differ from (*a*) in quality.

The asbestos included in portion (*b*) was freed as far as possible from the rock impurity by hand-picking and sifting at the Imperial Institute.

Samples of the asbestos representing both (*a*) and (*b*) were submitted to several firms of manufacturers and merchants.

(1) One firm stated that this type of asbestos was largely used in Germany, but that there is not much demand for it in the United Kingdom. They considered the samples to be of fairly good grade, and estimated their value in the United Kingdom, if there were a demand for this quality, to be about £45 to £50 per ton (May 1915). They added that they had recently paid about these prices for similar material.

(2) A second firm described the samples as of very good quality for this particular grade of asbestos. They stated that the value of such fibre, if over 1¼ in. long and of good colour, would be about £35 to £40 per ton, and if from ½ to 1¼ in. long about £28 to £30 per ton. The firm added that a large quantity of the blue asbestos

marketed is liable to be badly discoloured, and that this greatly affects the price.

(3) Another firm valued sample (*a*) at £35 per ton, and sample (*b*) at £28 10*s*. per ton c.i.f. English ports. They added that the demand for blue asbestos, although considerable, is not nearly so large as that for the white variety.

(4) A fourth firm stated that they were not themselves interested in blue asbestos, but they considered that both samples were of very fair quality, and that they should be saleable in the United Kingdom at prices ranging from £20 to £30 per ton.

It will be seen from these reports that the three firms who utilise blue asbestos place the value of material represented by the samples at from £28 to £50 per ton, the price varying according to the length and colour of the fibres. The fourth firm, who stated that they do not use blue asbestos themselves, valued the samples at a lower price.

The demand in the United Kingdom for crocidolite asbestos appears to be somewhat limited in comparison with that for the chrysotile variety, and the chief market for the former is stated to have been hitherto in Germany. Consignments of blue asbestos would, however, be saleable in the United Kingdom, and it is possible that a better demand might be created for it in this country. It seems doubtful, however, whether the material will realise at present such high prices in the United Kingdom as those which are stated to have been offered for it in Germany. Nevertheless, it is possible that, when better known, its value in this country will increase.

The material would require to be freed from rock impurity and to be graded according to the length of the fibres before export if satisfactory prices are to be obtained for consignments.

GENERAL ARTICLES

THE ECONOMIC RESOURCES OF THE GERMAN COLONIES

IV. Pacific Possessions

The present article is the concluding one of a series dealing with the economic resources of the German Colonies. It gives an account of the island possessions in the Western Pacific Ocean, which for purposes of administration are grouped into two divisions, called respectively German New Guinea Protectorate and Samoa, and it includes a summary of the trade of all the German Colonial possessions in Africa and the Pacific. For the sake of completeness a few notes are appended on Kiaochow, the only Asiatic dependency which has been held by Germany. Previous articles have described the agricultural, forest, and mineral resources of German East Africa, German South-West Africa, Cameroons, and Togoland (1914, **12**, 580; 1915, **13**, 110, 233, 392).

For the compilation of the part of this article dealing with the agricultural resources, which is largely based on information given in German Colonial Office reports, the Imperial Institute is indebted to Mr. A. H. Kirby, B.Sc., Assistant Director of Agriculture, Southern Provinces, Nigeria.

German New Guinea Protectorate

The islands and the part of New Guinea called German New Guinea may be described as being in the north-western part of Oceania known as Micronesia. There were originally two separate administrations: the "Altes Schutzgebiet," comprising the Bismarck Archipelago, part of the Solomon Islands and Kaiser-Wilhelmsland (part of New Guinea proper); and "Das Inselgebiet," including the East and West Caroline Islands with the Pelew and Marianne Islands and the Marshall Islands. In 1910 the financial administration of the Inselgebiet was joined to that of the Altes Schutzgebiet, with a central government at Rabaul. For the purposes of statistics the Inselgebiet has been divided into the Western Part (West Carolines, Pelew and Marianne

Islands), and the Eastern Part (East Carolines, Marshall Islands, and Nauru). It will be convenient to refer to the Inselgebiet and the Altes Schutzgebiet as Northern and Southern Micronesia respectively, the latter being taken to include the part of New Guinea that was owned by Germany.

New Guinea is the largest natural island, excepting the continent of Australia, in the world, and lies between the equator and 12° S. latitude and between 130° 50′ and 151° 30′ E. longitude. It is long and irregular in shape, extending in a direction north-west to south-east. The western half is Dutch New Guinea, whilst the eastern half is divided transversely into two parts, the northern section being Kaiser-Wilhelmsland, which became a German protectorate in 1884, and the southern section the British territory of Papua. The Dutch territory occupies about 49 per cent. of the whole area, the German 28 per cent. and the British 23 per cent. The estimated area of Kaiser-Wilhelmsland is 70,000 square miles, and the population 531,000 natives and 283 whites.

High ranges of mountains traverse the centre of New Guinea nearly parallel to both coasts. The Albert Victor mountains and the Sir Arthur Gordon range extend approximately parallel with, and to the south of, the boundary between the German and British sections of the island. In Kaiser-Wilhelmsland the Bismarck mountains are the principal range; other ranges, mostly of lower altitude, run parallel to the coast, the chief being the Prince Alexander mountains in the north-west and the Finisterre mountains in the south-east. The most important rivers in Kaiser-Wilhelmsland are (1) the Kaiserin Augusta, which, rising in the Charles Louis range in Dutch New Guinea and entering the Pacific near Cape della Torre, is navigable by ocean steamers for 180 miles, and (2) the Ottilien, a river of great length, which flows into the sea a short distance south of the last-named.

The chief town of Kaiser-Wilhelmsland and the seat of Government of the German New Guinea Protectorate is Rabaul. The chief harbours are Friedrich Wilhelmshafen and Konstantinhafen.

Off the coast-line of Kaiser-Wilhelmsland on the parallel of 6° S. latitude lies the Bismarck Archipelago (formerly the New Britain Archipelago), forming part of the German New Guinea Protectorate and comprising the Islands of New Pomerania (formerly New Britain), New Mecklenburg (formerly New Ireland), New Hanover and the Admiralty Islands, and nearly 200 smaller islands and islets. Bougainville and Buka of the Solomon group are included for administrative purposes in this portion of the German New Guinea Protectorate. The population of the Bismarck Archipelago, not including Bougainville and Buka, in 1913 was about 188,000 natives, 396 non-native coloured persons, mostly Chinese, and 685 whites.

New Pomerania, the most important island of the Bismarck Archipelago, is crescent-shaped, about 330 miles long and, except where the Willaumez Peninsula projects northward, is nowhere more than 60 miles wide. The total area is about 9,500 square miles. The island is in great part unexplored. The coasts are in some parts precipitous; in others the mountains recede inland and the coast is flat and bordered by coral reefs. The formation appears otherwise to be volcanic and there are some active craters. The greatest elevation—about 6,500 ft.—occurs towards the west. The chief harbours are Herbertshöhe and Simpsonhafen at the north of the Gazelle Peninsula.

New Mecklenburg is about 240 miles long, but in most parts less than 15 miles wide. It is mountainous throughout, with an extreme elevation of about 6,500 ft. in the north. The chief harbour is Namatanai.

The Admiralty Islands are a group of about forty islands, mostly of coral formation, lying to the north-west of New Pomerania. The largest, Manus, is about 60 miles in length and its highest point is about 3,000 ft. above the sea; the others are very small and rise little above sea-level. Most of the islands are of coral formation, but the hills of Manus are believed to be extinct volcanoes.

Bougainville is the principal island of the Solomon group and has an area of 3,900 square miles. It contains Mount Balbi, which is 10,170 ft. high, and two active volcanoes. Buka is a small island off the north coast of

Bougainville. The rest of the Solomon Islands, including Choiseul, Isabel, Malaita, Guadalcanar, and San Cristoval, are British.

The other islands comprised in the German New Guinea Protectorate are the Caroline, Pelew, and Marianne or Ladrone Islands (except Guam), which became German possessions in 1889, and the Marshall Islands, which were taken over by Germany in 1906. Guam, the largest of the Marianne Islands, belongs to the United States of America.

The Carolines consist of about 500 coral islets with a total area of about 380 square miles, of which the four main islands, Ponape, Kusai, Truk or Hogolu, and Yap, cover 307 square miles. These four islands are of considerable elevation—the highest point of Ponape approaches 3,000 ft.—but the rest are generally low coral islets. The population of Ponape numbers about 2,000, that of Yap 7,155, and Kusai 400.

The Pelew Islands, to the west of the Carolines, are about 26 in number, with a total area of 175 square miles. The islands in the south of the group are of coral, those in the north of volcanic rocks. The total population is about 3,100, the bulk of whom inhabit the largest island, Babelthuap.

The Marianne or Ladrone Islands lie in the north-western Pacific Ocean, in latitude 12° to 21° N. and longitude 145° E., and consist of two groups. The northern group comprises ten volcanic main islands, of which only four (Agrigan, Anatahan, Alamagan, and Pagan) are inhabited. In this group an extreme elevation of about 2,700 ft. is reached, and there are craters showing signs of activity, while earthquakes are not uncommon. The southern group consists of five coralline limestone islands (Rota, Guam, Aguijan, Tinian, and Saipan), all inhabited except Aguijan. Coral reefs fringe the coasts of these isles, which are of slight elevation. The total area of the islands, excluding Guam, is about 245 square miles and the population 2,500.

The Marshall Islands, annexed by Germany in 1885-1886, consist of a number of atolls of coralline formation

ranged in two almost parallel lines extending north-west to south-east between 4° and 15° N. latitude and 161° and 174° E. longitude. The north-east line, with fifteen islands, is called Ratak, the other, with eighteen, Ralik. The total area of the group is estimated at 160 square miles. The chief island and seat of government is Jaluit, and the most populous island is Majera with 2,600 inhabitants. The highest elevation occurs on the island of Likieb and is only 33 ft. A wireless station was erected by the Germans at Nauru, or Pleasant Island.

Climate

Judging from the meteorological observations available, the Bismarck Archipelago experiences a comparatively dry season from August to November, whilst a proportionately heavy rainfall is received in the period December to April. These islands are usually favoured with a good rainfall, although in the largest of them (New Pomerania and New Mecklenburg) the dry season may be sometimes severe. The part of the Solomon Islands recently under German control has a very irregular precipitation, with no definite wet and dry seasons; the amount of rain received varies considerably from year to year, *e.g.* in 1911 it was 7·98 in. as compared with 150·7 in. in 1910 and 173·1 in. in 1909. The observations in Kaiser-Wilhelmsland have been confined in the main to the coast regions. These enjoy the conditions common to the meteorological area in which they are situated, although parts of the coast lying near together often receive very different amounts of rain.

In Northern Micronesia, the Marshall Islands (as far as observations go) appear to receive a rainfall of about 150 in. in normal years; in Yap, the Pelew Islands, Saipan and Jaluit, very dry weather in December to March is likely to cause a serious want of water. The other parts of this area (the Caroline and Marianne Islands) share, generally speaking, the conditions of rainfall of the Marshall Islands. The island of Nauru, noted for its production of copra and phosphate, suffered in 1911 from a phenomenal rainfall of 469·1 in., accompanied by a constant, strong

westerly wind which damaged the coconut palms and often prevented the loading of the phosphate steamers.

Typhoons have been reported in recent years, chiefly from Rota, Jaluit, Yap, and the Pelew Islands, the northern part of the last-mentioned being almost devastated in 1912. These storms are to be expected mostly in Northern Micronesia.

Plant and Animal Production

Copra is by far the most important plant product of Micronesia. The only other vegetable products that are exported to any extent come from the southern part (Bismarck Archipelago, Solomon Islands, and Kaiser-Wilhelmsland), and include rubber and gutta percha, cocoa, ivory nuts, and Sisal hemp.

Plantations.—During recent years there has been an increasing demand for land for plantations on the part of others than natives. In 1912 this development had reached the following position:

Part of Colony.	Plantations laid out.	Cultivated areas.	Increase of cultivation over areas of previous year.
	Acres.	*Acres.*	*Acres.*
East Carolines, Marshall Islands, and Nauru	6,500	3,850	133
West Carolines, Pelew, and Marianné Islands	4,250	3,725	1,650
Kaiser-Wilhelmsland	180,000	17,475	875
Bismarck Archipelago and Solomon Islands	270,000	55,750	7,750
Total	460,750	80,800	10,408

Of the total cultivated area of 80,800 acres, the coconut occupies 73,000 acres, leaving 7,800 acres for other plants, such as rubber (Ficus, Castilloa, and Hevea) and cocoa; but a certain amount of rubber is also grown as a mixed cultivation with coconuts, the area being included in the figure quoted for the latter crop. Rice, coffee, and Sisal hemp are also cultivated in plantations, but only in isolated experimental areas. The enormous extension of coconut cultivation is attributed to: (1) the promising condition of the soil for the culture; (2) the simplicity of the culture and of the preparation of the crop; (3) the acquaintance of the natives with the palm, and the consequent usefulness

of the labourers; and (4) the high prices that have ruled for copra.

Trials have been made to find a suitable catch-crop for coconut plantations, maize, sugar-cane, and arrowroot having been planted for this purpose, but the results were not altogether successful. Manila hemp has been grown to some extent in Saipan and Kusai. Copra preparation has been largely assisted by the erection of driers. The exploitation of other products is hindered by the want of labour, arising from the interest in the coconut and the disinclination of the natives to travel any distance when wanted for work.

Native Cultivation.—As in the case of the plantations conducted by non-natives, the coconut palm is the chief crop grown by the natives, and the copra produced by them forms by far the greatest proportion of the exports. The native plantations exist chiefly in Friedrich-Wilhelmshafen, New Mecklenburg, Kieta, the Gazelle Peninsula, and North-west Baining. Steady progress appears to have been made, although this is hindered by adherence to old customs, notably that of "taboo," which often prohibits for use and export the production from large numbers of palms. The native copra from this colony has come into bad repute; not, it is said, from poor preparation, but through the inclusion of green nuts ("kulau") when it is being made. Instruction in this work and the provision of copra driers are much needed. The best native copra appears to come from the western islands of Northern Micronesia; here the natives sell the whole nuts to traders who make the copra, with the result that the soil of their plantations loses the manurial value of the rotted shells. The high prices that have ruled for copra in recent years have not tended towards an improvement in its quality, as the native producer has been enabled to get a profitable price for the inferior kinds.

Near Blanche Bay the natives grow annual crops in fairly large quantities for the provision of labourers' food on the plantations owned by others than natives.

Pests.—The chief insect pests are a rhinoceros beetle, a locust or grasshopper, and a shield scale which affect the

coconut palm exclusively, but do not appear to cause extensive damage. The first-mentioned insect is most prevalent in those parts of plantations lying nearest to the primeval forest; it has been controlled by the removal of the larvæ from the young palms. Reports of the prevalence of the shield scale come chiefly from the islands of Nanuk and Yap and from the Pelew Islands; where measures for control are taken, these consist in clean cultivation and the removal and burning of affected plants and parts of plants.

The principal damage to the cocoa, which is of the Criollo variety, has occurred from pests in the Petershafen-Witu group. Both this plant and Hevea grow very badly in places where sea-breezes are especially prevalent.

Animal Production.—This is of little importance in the colony at present. Government stations have existed at Kaewing and Kieta, for the breeding of sheep and cattle respectively; the improvement of the sheep has been sought chiefly in importations from Java for inter-breeding. The native stock consists mainly of pigs and fowls, although cattle-breeding exists in Saipan and Rota. Among stock diseases, sheep-rot alone exists to any extent.

Exploitation of Wild Products.—The activity in the collection of rubber and gutta percha is very small in comparison with the resources available. It obtains chiefly in the primeval forests of Kaiser-Wilhelmsland, whence the export takes place through Friedrich-Wilhelmshafen. Malay instructors have been introduced for the improvement of the industry, but little progress has been made. In Morobe a certain amount of dammar resin and rattans are collected by the natives, in addition to gutta percha of poor quality.

The small amount of timber that is cut is used mainly in the Possession itself.

The tables at the end of this article show that there is a valuable export of birds-of-paradise skins from German New Guinea. The birds are exploited chiefly by European gold prospectors and small planters, who employ native hunters for the collection. The restrictions on this have been increased in late years by an extension of the close season and the formation of three large preserves for the birds.

Among sea products, the production of turtle shell has decreased in recent years, whilst that of trepang has fluctuated greatly. The richest banks and reefs have shown exhaustion; so that some of the fisheries, notably in the Pelew Islands, have been allowed time for recuperation. In the Admiralty Islands, a concession for a pearl fishery, worked with Japanese and Malay divers, has not so far indicated success.

Mineral Resources

The higher ground of the central axis of New Guinea is largely built up of metamorphosed rock (schists and slates), together with the igneous rocks (granites, diorites, etc.) intrusive in them. These metamorphosed rocks are partly Palæozoic and partly also probably pre-Cambrian in age. They show in general a steep dip and a north-west strike. A considerable degree of mineralisation has accompanied the intrusive activity in some cases, as is shown by the occurrence of gold in connexion with dioritic and other intrusions.

The older rocks are succeeded by Mesozoic and Tertiary beds, including fossiliferous limestones, marls, and clays. Cretaceous beds with a north-north-westerly dip of 85° occur in the Torricelli mountains in the north-west of Kaiser-Wilhelmsland. Coal and oil are found in the Tertiary strata.

Overlying the Cretaceous and Tertiary beds of Kaiser-Wilhelmsland are still younger alluvial deposits and coral-reef masses. Associated with the youngest deposits are volcanic rocks, which indicate comparatively recent volcanic disturbances. Indeed, a large part of New Guinea owes its emergence from the sea to the uplifting earth-movements and accompanying eruptive activity that took place during Tertiary times; and although much of the high ground of the island is composed of old rocks that have been long exposed to weathering, certain of the high mountains are built of Cretaceous limestones. These Cretaceous limestones have been raised to a height of over 14,000 ft. above sea-level in the Wilhelmina range, a fact which, taken in conjunction with the existence of Tertiary

beds and their associated volcanic rocks over large areas, shows how important a part Tertiary earth-movements and eruptive activity have played in determining the physical features of New Guinea and the surrounding region.

The neighbouring islands have much in common with New Guinea as regards their geology. Coral limestones form an important part of many of them, and this is especially the case with the oceanic islands, such as those of Nauru (Pleasant Island) and Angaur, which are economically important on account of their extensive phosphate deposits.

The chief mineral product of the German Pacific islands is phosphate. Various other economic minerals have been found, but not in sufficient quantity as yet to become of any commercial value, though in view of their possible future importance it is desirable that some mention should be made of the occurrence of gold, oil, coal, and other minerals.

Phosphates.—Among the various Pacific coral islands that are important as sources of phosphates, Nauru or Pleasant Island and Angaur figure prominently. Nauru is in the Marshall group of islands. Angaur is a small island in the Pelew group. As in the case of Ocean Island, the phosphate rock exploited on these islands has arisen from the leaching of surface guanos and the consequent phosphatisation of the underlying coral limestone.

In nature and mode of origin the deposits resemble those of Assumption Island in the Seychelles, described in a former volume of this Bulletin (1911, **9**, 39). The extent to which this phosphatisation has gone on is indicated by the fact that the Nauru phosphate rock may contain as much as 87 per cent. of tribasic calcium phosphate. An analysis of a Nauru sample gave phosphoric acid 37·35 per cent., lime 49·72, water and organic matter 6·04, and other constituents 6·89. Both on account of the high percentage of phosphate of lime and the low percentage of alumina and iron oxide, the phosphate rock of Nauru is of excellent quality. The deposits are very extensive, and though the depth to which they extend has not been ascer-

tained, some idea of their extent may be formed from the estimate that Nauru and Ocean Island together contain probably not less than 50,000,000 tons of phosphate rock. The deposits of Angaur are less extensive, and are estimated at about 2,500,000 tons, most of which contains not less than about 80 per cent. of tribasic calcium phosphate.

The total exports of phosphate from Nauru and Angaur during 1912 amounted to 193,000 tons, valued at about £250,000. It is chiefly to the Pacific countries, Australia, New Zealand and Japan, that the phosphates from Nauru and Angaur have been exported, although a certain quantity has been shipped to Europe (see tables, p. 572).

Gold.—The fact that important alluvial deposits of gold have been worked for some years in Papua (British New Guinea) would lead one to expect that workable gold deposits should occur also in the German part of the island, especially when the probable origin of the gold is taken into consideration. The gold appears to have been derived from the old metamorphic rocks. It occurs in quartz veins in these old rocks in some localities, but although some mining has been carried on among such quartz veins in Papua, the gold has been obtained chiefly from the alluvial deposits. In view of the possibility of gold discoveries in Kaiser-Wilhelmsland, it is of interest to note that the gold output of Papua for the year ending June 30, 1914, was 14,666 oz., valued at £50,110, and it is believed that suitable areas for dredging exist on the Mambare, Gira, and Lakekamu rivers.

Up to the present, however, the prospecting operations that have been carried on in search for gold in Kaiser-Wilhelmsland seem not to have revealed any important deposits. Gold occurs in some of the rivers traversing German territory, as in the Wiwo and Waria rivers, but not in deposits so rich as those in British territory, so far as is at present known. It seems probable, however, that auriferous quartz veins will be found associated with some of the intrusions occurring in various localities; and alluvial deposits may be found when the country has been more fully explored.

Petroleum.—Recent investigations in New Guinea have

shown clearly that petroleum occurs in the younger strata of the island, and though it yet remains to be ascertained whether the deposits so far discovered will prove to be of any economic importance, the indications are very promising (see this BULLETIN, 1915, **13**, 185). Oil has been observed also in Dutch territory, in the district south of the Nassau range, where it occurs as an impregnation of strata of probable Tertiary age. In this region it is reported that at one locality forest trees had been killed by oozings of kerosene oil.

In the German portion of New Guinea, oil has been found in the Eitape district on the north coast. The samples examined showed a high percentage of heavy oil. This region in the north-west has within the last two or three years been reserved by the administrative authorities for the purpose of carrying out a special investigation of its oil possibilities.

Coal.—Coal is reported to occur in the younger rocks of Kaiser-Wilhelmsland. The only coal hitherto found appears to be of the brown coal variety, similar to that occurring at various localities in Papua. Such brown coal has been found in the vicinity of Astrolabe Bay, and an analysis of a sample of this gave carbon 53·5 per cent., hydrogen 3·85, oxygen and nitrogen 19·87, ash 4·84 and water 17·94 per cent. The calculated calorific value was 4638. This analysis indicates that the brown coal of the Astrolabe Bay district is closely similar to that of the Purari valley in British territory. The brown coal of the latter locality is of Tertiary age, and contains on the average about 17 per cent. of water in the samples so far analysed.

These occurrences, taken in conjunction with the occurrence of coal in probable Tertiary beds associated with oil in Dutch territory, indicate a wide distribution in New Guinea of brown coal of possible local importance from an industrial standpoint. Hitherto no coal older than Tertiary has been found in the island.

Other Minerals.—Other noteworthy mineral occurrences in Kaiser-Wilhelmsland include that of native copper in a rolled fragment of basalt found in the Kabenau river. It should be mentioned in this connexion that the ores of the

Astrolabe copper-field in Papua probably owe their origin to basic intrusions, since they are intimately associated with intrusive gabbros and basaltic volcanic rocks.

Still more basic igneous rocks, of the peridotite and serpentine type, occur in various parts of Kaiser-Wilhelmsland. Diamonds, chromite, platinum, and iridium may reasonably be sought for in these rocks, and osmiridium has already been found in the Gira river and other places in Papua.

Graphite is reported to occur among the older metamorphic rocks of the interior of New Guinea, and there is a possibility that graphitic schists and gneisses containing lenticles of graphite may occur among these old rocks.

Among the younger sedimentary strata of the country, limestones and clays appear to be abundant, and these would doubtless furnish plenty of material that could be used for the manufacture of bricks, cement, and other products required for use in building construction.

Exports

The following tables show the chief exports from the German New Guinea Protectorate in 1910, 1911, and 1912, arranged under its three divisions:

I. *Bismarck Archipelago, Solomon Islands, and Kaiser-Wilhelmsland*

	1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Cocoa	39	2,772	63	3,638	73	3,733
Copra	9,095	151,956	9,399	166,597	11,190	202,603
Ivory nuts	115	1,603	75	1,015	116	1,308
Rubber	6	3,390	11	4,562	21	7,787
Sisal hemp	13	413	7	192	21	523
Trepang	58	936	49	1,072	88	1,404
Turtle shell	1,265 lb.	799	1,126 lb.	741	1,190 lb.	925
Mother-of-pearl and other shells	307	4,635	359	8,096	315	6,261
Birds-of-paradise skins	5,706 pieces	8,545	8,779 pieces	13,924	9,837 pieces	22,463
TOTAL EXPORTS	—	181,130	—	205,471	—	252,055
TOTAL TRADE (exports and imports)	—	364,383	—	470,408	—	545,647

The greater part of these exports went to Germany, the only product of importance shipped elsewhere being

copra, of which 1,000 tons valued at £19,689 were sent to Australia in 1912.

II. *East Caroline Islands, Marshall Islands, and Nauru*

	1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Copra	4,253	49,199	4,022	46,620	4,747	82,819
Phosphate	140,381	428,025[1]	87,041	265,389[1]	136,496	173,406
TOTAL EXPORTS	—	479,455	—	313,559	—	258,184
TOTAL TRADE (exports and imports)	—	557,659	—	400,033	—	356,316

[1] *The comparatively high values in* 1910 *and* 1911 *are due to the inclusion in the figures of phosphate sold but not exported.*

The destinations of the copra and phosphate exported in 1912 were as follows:

	Copra.		Phosphate.	
	Quantity. *Tons.*	Value. £	Quantity. *Tons.*	Value. £
Germany	1,766	26,363	42,457	53,938
Australasia	1,333	25,738	52,050	66,125
Asia	103	901	41,989	53,343
America	915	17,657	—	—
Europe, excluding Germany	630	12,160	—	—

III. *West Caroline Islands, Pelew Islands, and Marianne Islands*

	1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Copra	944	14,522	870	11,805	1,085	15,091
Mother-of-pearl shells	261	6,096	269	6,654	70	1,630
Phosphate	35,380	46,847	43,932	62,510	53,525	76,160
TOTAL EXPORTS	—	72,665	—	82,312	—	94,101
TOTAL TRADE (exports and imports)	—	110,164	—	131,644	—	162,730

In 1912 the destinations of the exports of copra and phosphate were as follows:

	Copra.		Phosphate.	
	Quantity. *Tons.*	Value. £	Quantity. *Tons.*	Value. £
Germany	69	1,346	12,299	17,500
Australasia	—	—	10,331	14,700
Asia	142	3,026	17,907	25,480
Europe, excluding Germany	874	10,719	12,988	18,480

SAMOA

The two largest islands of the Samoan Archipelago, namely Savaii and Upolu, became a German dependency in 1899. The islands are in the Pacific Ocean, nearly midway between the New Hebrides and Tahiti, and 1,600 miles from Auckland, New Zealand. Savaii has an area of 660 square miles and a population of 12,816. The area of Upolu is 340 square miles and the population about 18,000. Several fertile and populous islets in the vicinity are included in the German dependency. The islands are considerably elevated, with several extinct or quiescent craters rising from 2,000 ft. in Upolu to 4,000 ft. in Savaii. In comparatively recent times, probably in the seventeenth or eighteenth century, Upolu has been subject to volcanic disturbances, although there are at present no active volcanoes. Apia and Saluafata are important harbours in Upolu.

The forests of Samoa contain coconut and bread-fruit trees, which are of value to the natives as means of sustenance, and some useful timber trees, which supply material for boat-building. A large proportion of the inhabitants of the islands are engaged in agricultural pursuits, the chief crops being copra and cocoa. No minerals of economic importance have hitherto been recorded.

Climate

The results of observations at Apia extending over twenty-three years have indicated a mean average rainfall of 118 in., and have demonstrated that there is a well-marked three-yearly recurrence of maximum rainfall, *e.g.* in 1892, 1895, 1898, 1901, 1904, 1907, and 1910, the average being 146 in. In the times of minimum rainfall between these years the average was just under 83 in. In Upolu and Savaii the rainfall varies broadly between 100 and 150 in. The dry season, when the south-east trade wind blows regularly, is the coolest time of the year. At this period, the average vapour-pressure in the air is about

75 per cent., as compared with 80 to 85 per cent. in the wet season.

The normal yearly mean of temperature is about 80° F. The hottest time is in or near March, and the coolest about July, the highest and lowest temperatures being respectively in the neighbourhood of 90° and 65° F.

The activity of the volcano Matavanu, in Savaii, has continually diminished during recent years, so that vegetation is covering the lava field, and plantations in the area near the volcano have suffered in a diminishing degree from the emitted vapours. At the same time the frequency of thunderstorms and the accompanying injury done to palms by lightning have decreased, but it cannot yet be certain if this is a natural accompaniment of the lessening vulcanicity.

Agricultural Products

General.—The lack of water in the drier years of the three-yearly periods, especially when the rainfall is badly distributed, often causes a serious shortage for domestic uses and for stock. Little damage is to be apprehended from storms at any time. There has been a gradual extension of systematic planting among the natives, who have learned to control more effectively the rhinoceros beetle (*Oryctes Rhinoceros*), the chief enemy of the coconut palm. The number of plantations registered as being owned by others than natives increased from 133 in 1911 to 141 in 1912.

Copra.—This is by far the most important product of Samoa. The quantities exported depend mainly on the amount and distribution of the rainfall, although when this is below the average the quality of the copra improves through the better drying. The production has been increasing in every part of Samoa, except the western part of Savaii where the soil is not favourable to the growth of the palm. It is estimated that about one-third of the total production of copra in Samoa comes from plantations having white owners.

Cocoa.—This is second in value to copra. The area

under cultivation in 1912 was 9,033 acres against 5,453 acres in 1911; it seems that the culture would be taken up more extensively but for the somewhat discouraging prevalence of cocoa canker (see p. 576), especially as this and other diseases increase largely in extent in the wettest years. Observations have shown so far that places with a smaller rainfall, such as the district of the north-west coast of Upolu, afford more favourable conditions for cocoa than the rainy and higher-lying regions like those in the vicinity of Apia.

Rubber.—The production is almost entirely in plantations of Hevea, the area of these in 1912 being 2,715 acres as compared with 1,935 acres in 1911; the areas of tappable trees were in the respective years 513 and 338 acres. Out of an export of 23,778 lb. of rubber in 1912, 17,631 lb. came from the plantations of a single company, where the average daily yield of dry rubber from each tree is stated to have been: 1910, 195 grams; 1911, 450 grams; 1912, 830 grams. Want of labour has interfered with the tapping operations of this and other companies.

Kava Root.—This drug, the product of *Piper methysticum*, Forst., has been used in the South Sea Islands in the preparation of an intoxicating liquor, and was at one time largely exported from Samoa to neighbouring islands. In recent years, however, there has been a diminishing export to the Tonga Islands, owing to the increasing production in that Protectorate, whilst a large trade with Fiji has been considerably lessened owing to the restrictions on the importation of plant material from Samoa which have been enforced to prevent the introduction of the rhinoceros beetle. Since 1911 practically the whole of the material exported has been sent to Germany.

Coffee.—Very little attention is given to coffee growing, partly, it is said, because of the unsuitability of the conditions. The comparatively small quantities produced are consumed almost entirely locally, and there has only been an inconsiderable export of a few hundred pounds.

Tobacco.—In this case, again, the export (chiefly to the Tonga Islands and Fiji) amounts to only a few hundred pounds from year to year. The cultivation is almost ex-

clusively in the hands of the natives, chiefly for supplying their own needs.

Pineapple.—Although the pineapple thrives well in Samoa, there has been little attempt to develop it as a product for exportation, but in 1912 a company was formed for this purpose.

Animal Production.—Stock-keeping in Samoa is largely carried on in connexion with coconut cultivation on plantations owned by Europeans. Cattle and horses, and even pigs, fowls, and ducks, have been imported from neighbouring British possessions for improving the stock, horses coming chiefly from New Zealand and small stock from Australia.

Measures against Plant Pests and Diseases.—It has been indicated that a rhinoceros beetle (*Oryctes Rhinoceros*) is the chief enemy of coconut cultivation in Samoa. The chief measures adopted against the pest have been: (*a*) the destruction of old coconut wood and shells lying about the plantations; (*b*) the use of this material as traps, which were burned after six or eight weeks; (*c*) the promulgation of a "duty day," in which all Samoan males had to make a thorough search in the native plantations for pests, with a view to their destruction. In addition to these measures, there has been an attempt to introduce a natural enemy of the beetle. The pest attacks especially groups of young palms, and extends in the direction of the prevailing winds. The want of labour hinders the proper control of the insect, and it is hoped that the importation of Chinese may help to meet this difficulty.

Canker of cocoa, due to *Phytophthora Faberi*, has apparently had a most serious effect in retarding the extension of cocoa growing. It is in wet years that its damage and spread are chiefly felt, whilst its outward manifestations seem to be almost absent during the comparatively dry periods. When the rainfall is heavy the condition is aggravated by the fact that many of the plantations are inundated and consequently the disease spreads quickly, the trees being attacked in large numbers at the collar. Here, again, the want of labour has hindered the attempts to cope with the disease. Measures against cocoa canker

in Samoa have included: (*a*) the removal of shade trees in many places; (*b*) the quick destruction, by burning, of the broken shells lying about in the plantations (a measure also against the rhinoceros beetle); (*c*) the use of disinfecting (fungicidal) substances; and (*d*), the most useful measure, consisting in the agricultural care of the trees. In 1912 the presence of the disease on Hevea was established; the fruits and the bark were the parts attacked, but the condition was observed in only a few cases.

Pink disease, due to *Corticium javanicum*, is the chief among other plant diseases in Samoa. It has been found on several kinds of plants, especially in the years of greatest rainfall.

Exports

The chief exports from Samoa in 1910, 1911, and 1912 are shown in the following table:

	1910.		1911.		1912.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Copra	8,996	148,564	10,072	179,145	11,021	203,496
Cocoa	497	27,753	632	38,508	722	41,983
Rubber	—	—	1	646	12	5,538
Kava roots	3	280	12	1,130	17	1,040
TOTAL EXPORTS .	—	176,688	—	219,499	—	252,224
TOTAL TRADE (exports and imports)	—	349,805	—	422,811	—	501,944

The values of the chief exports in 1913, together with the countries of destination, were as follows:

	Australasia.	Germany.	United States.	Other countries.	Total.
	£	£	£	£	£
Copra . . .	100,071	97,685	3,960	4,328	206,044
Cocoa . . .	2,141	44,474	1,070	5,488	53,173
Rubber . .	9	3,290	—	1,242	4,541
Kava roots . .	—	3,204	—	—	3,204

SUMMARY OF TRADE OF THE GERMAN COLONIES

I. Total Exports and Trade

	1911. Total exports.	1911. Total trade (exports and imports).	1912. Total exports.	1912. Total trade (exports and imports).
	£	£	£	£
German East Africa	1,121,888	3,416,470	1,570,919	4,086,377
German South-West Africa	1,428,662	3,693,760	1,951,767	3,576,712
Cameroons	1,062,544	2,528,420	1,166,811	2,878,890
Togoland	465,878	946,879	497,945	1,069,336
German New Guinea Protectorate:				
Bismarck Archipelago, Solomon Islands, and Kaiser-Wilhelmsland	205,471	470,408	252,055	545,647
East Caroline Islands, Marshall Islands, and Nauru	313,559	400,033	258,184	356,316
West Caroline Islands, Pelew Islands, and Marianne Islands	82,312	131,644	94,101	162,730
Total, German New Guinea	601,342	1,002,085	604,340	1,064,693
moa	219,499	422,811	252,224	501,944

I. Chief Articles of Export in 1912, arranged in Order of Value

Product.	Total value.	Exporting country.	Values from each country.
	£		£
Diamonds	1,520,704	German S.-W. Africa	1,520,704
Rubber and gutta percha	1,057,391	Cameroons	573,611
		German E. Africa	421,310
		Togoland	48,787
		German New Guinea Protectorate	8,145
		Samoa	5,538
Copra	585,225	German New Guinea Protectorate	300,513
		Samoa	203,496
		German E. Africa	78,152
		Togoland	3,064
Palm kernels	389,286	Cameroons	220,308
		Togoland	168,978
Sisal hemp	368,484 [1]	German E. Africa	367,961
		" New Guinea Protectorate	523
Copper ore	326,163	" S.-W. Africa	326,163
Cocoa	270,680	Cameroons	212,114
		Samoa	41,983
		Togoland	12,151
		German New Guinea Protectorate	3,733
		" E. Africa	699

[1] *Excluding a very small quantity of Sisal hemp from Togoland, the value of which is not recorded separately.*

Product.	Total value.	Exporting country.	Values from each country.
	£		£
Phosphates	249,566	German New Guinea Protectorate	249,566
Hides and skins	220,959	" E. Africa	203,368
		" S.-W. Africa	16,368
		Cameroons	614
		Togoland	609
Palm oil	151,762	Cameroons	81,119
		Togoland	70,643
Cotton	131,270	German E. Africa	105,512
		Togoland	25,745
		Cameroons	13
Coffee	95,412	German E. Africa	95,168
		Togoland	147
		Cameroons	77
		German New Guinea Protectorate	14
		Samoa	6
Ground nuts	64,975	German E. Africa	63,602
		Togoland	1,309
		Cameroons	64
Timbers	48,136	"	34,793
		German E. Africa	11,857
		" S.-W. Africa	788
		" New Guinea Protectorate	572
		Togoland	126
Ivory	47,222	Cameroons	26,810
		German E. Africa	18,056
		Togoland	2,085
		German S.-W. Africa	271
Beeswax	41,459	" E. Africa	41,453
		Cameroons	6
Live animals	36,865	Togoland	30,737
		German S.-W. Africa	2,671
		" E. Africa	2,183
		Cameroons	1,274
Gold	26,531	German E. Africa	26,531
Sesame seed	26,186	" " "	26,186
Mica	24,075	" " "	24,075

KIAOCHOW

The former German Protectorate of Kiaochow lies on the east coast of the Chinese Province of Shantung, about 150 miles south-west of the British possession of Weihaiwei. The actual territory included in the Protectorate comprises the coast-line of Kiaochow Bay and the land north and south of its entrance, the total area being 193 square miles. A zone of neutral territory, 30 miles broad, with an area of about 2,750 square miles, however, came within the German sphere of influence. The population of the

Protectorate in 1913 was 192,000, the white population, including the garrison, being 4,470, of whom 3,806 were Germans.

The position is one of great strategic strength, and the Germans spent large sums of money on its development. The harbour works at Tsingtau, the chief port, are stated to be among the best in East Asia. There is a large and important shipbuilding yard provided with a 16,000-ton floating dock and a mile of quays, where ships of war and trade can be docked and repaired, and a smaller harbour for coasting craft and junks. In order to open up the valuable trade of the Shantung province, a railway was constructed from Tsingtau to Tsinan (Chinanfu), the capital of the province, with a branch line to Poshan.

The chief agricultural products are barley, millet, wheat, beans, ground nuts, fruits, sweet potatoes, and tobacco. Most of the exports from Tsingtau are derived from the Shantung province; the chief exports in recent years are shown in the following table:

Principal Exports from Kiaochow

Article.		Year 1911.	Year 1912.	Year 1913.
Live cattle	number	5,835	16,665	28,413
Meat, fresh or frozen	tons	449	751	5,179
Eggs	number	17,502,350	20,834,840	27,056,000
Wheat	tons	21	270	511
Beans	,,	543	569	816
Walnuts	,,	947	890	1,685
Ground nuts	,,	4,094	2,818	7,308
,, ,, shelled	,,	44,040	47,117	54,228
Ground-nut oil	,,	9,635	17,125	10,647
Soy-bean oil	,,	8,742	5,631	5,502
Bean cake	,,	3	4,242	7,173
Cotton, raw	,,	2,391	4,376	3,142
Hemp	,,	—	687	275
Silk, raw	,,	180	389	292
,, refuse or waste	,,	429	638	511
,, Shantung pongees	,,	208	235	410
Straw braid	,,	5,238	6,234	5,195
Wool, sheep's	,,	124	203	184
Bristles	,,	175	134	219
Hides, cow and buffalo	,,	428	1,700	2,313
Goat skins, untanned	pieces	54,534	489,783	131,826
Tallow, animal	tons	521	468	1,896
Salt	,,	7,480	32,452	20,922
Coal	,,	106,498	126,334	167,860

The total value of the exports in 1913 was £3,880,619, as against £3,815,006 in 1912. The values of the direct exports to foreign countries in the same years were £1,957,000 and £2,662,180 respectively. The chief foreign countries receiving the exports in 1913 were, in order of importance, France, Russia, Germany, and Japan.

CASSAVA: ITS CULTIVATION AND UTILISATION

THE cassava plant, known also as manioc and mandioc, is a native of Brazil, where it has been cultivated from time immemorial. It is now grown in almost every part of the tropics, its tuberous roots often forming the chief source of food of the natives. In European countries the best-known product of the plant is tapioca, but in recent years the starch obtained from the roots has been utilised industrially as a source of alcohol, glucose, and dextrin, and as a sizing material for yarns and fabrics. The roots themselves, after suitable preparation, and the residues of the tapioca and starch factories, are largely used as a feeding-stuff for live-stock. Within the last few years considerable interest has been taken in the crop as a source of starch in the West Indies, where the roots have long been cultivated as a foodstuff. Factories for the manufacture of cassava starch have already been erected in Jamaica, Trinidad, and elsewhere.

VARIETIES

Cassava is a Euphorbiaceous plant belonging to the genus *Manihot*, and is thus closely related to the Ceara rubber tree (*Manihot Glaziovii*, Muel. Arg.). It is a much-branched shrub which reaches a height of 12 to 16 ft. when allowed to grow naturally, but under cultivation seldom exceeds 6 to 10 ft. The leaves are palmately divided, the number and shape of the lobes varying according to the variety. The flowers are unisexual and are borne in loose, spreading clusters near the ends of the shoots, the male and female flowers being produced on the same plant. The fruit is a drupaceous capsule, containing three seeds, each

almost as large as a castor-oil seed. The large, swollen root tubers are formed in clusters at the base of the stem; they vary in size and number in the different varieties, but are usually from 1½ to 4 ft. long, and 1½ to 2½ in. in diameter when gathered, though they may attain a much greater size if allowed to grow for several years.

Two forms of cassava are cultivated. That most widely grown throughout the tropics is the "bitter" cassava, which yields fairly considerable quantities of hydrocyanic acid (prussic acid) from all parts of the root. The second form is the "sweet" cassava, which also yields hydrocyanic acid, but in this case it is derived mainly from the outer cortical layer or skin (see p. 595). They are frequently regarded as distinct species, the first being *M. utilissima*, Pohl (*Jatropha Manihot*, Linn.; *Janipha Manihot*, Kunth), and the second *M. palmata*, Muel. Arg. (*M. Aipi*, Pohl.; *M. dulcis*, Baill.; *Jatropha dulcis*, Rottb.). The two plants, however, are extremely difficult to distinguish in the field, and some botanists consider that the sweet cassava is merely a variety of the bitter form evolved in the course of time by cultivation.

Peckolt, in an account of the cassava plants grown in Brazil, describes *M. utilissima* as a vigorous-growing plant, with dark-coloured leaves, greenish-red or reddish on the under surface, and with red or reddish-purple leaf stalks. The stems and branches vary in colour from bright green to blackish and frequently have a reddish tinge; they are always more or less lactescent. The tubers are large with a brown or reddish-brown epidermis of firm texture which can only be removed, as a rule, by scraping; the cortex is white and fleshy, at least 2 mm. thick or as much as 5 mm., and possesses abundant acid latex; the interior of the root is also more or less lactescent and slightly fibrous. *M. palmata*, according to the same author, is less robust, with bright green leaves, whitish or greyish on the under surface. The petioles, stems, and branches are never red, but vary from bright green to greenish-brown. The tubers are smaller than in the other species, and the epidermis is thin, yellowish or light brown, and is easily removed without scraping; the cortex, which is fleshy and white, is

about 1 mm. thick, never more than 2 mm., and possesses a comparatively small quantity of very clear, neutral latex; the interior of the root contains no latex and is fibrous in the centre.

Dûss, in his *Flore de la Martinique*, says that the stem of the sweet cassava is not angular, and that the stipules are winged, whereas in the bitter cassava the stipules are rudimentary or represented by a prickle with a broad base, whilst the lobes of the leaves of the sweet cassava are somewhat larger, and less tapering than those of the other plant.

Although the characters quoted above may be true of the plants grown in the countries mentioned, they do not appear to be of universal application. In Travancore, India, for example, the leaf-stalks and stems of several races of sweet cassava are pink or red, and in one case bright scarlet. In Colombia, again, where all the varieties are sweet, the stems are of various colours, ranging from grey and slate to deep red. Even the toxic character of the root does not appear to be fixed. In West Africa, three varieties are stated to occur, known as white, red, and black, according to the colour of the stem. In Dahomey the roots of all three varieties can be eaten with impunity without special treatment; but two of them, the red and the white, when grown on forest soil in Nigeria, are stated to be extremely poisonous, yielding large quantities of hydrocyanic acid.

Cultivation

Climate and Situation

Cassava is essentially a tropical plant, and can only be grown profitably in regions free from frost for at least eight months during the year. Its growth is stopped by a slight frost or even by continued cold weather. Sweet cassava is hardier than the bitter variety, and is consequently almost the only form grown in regions farthest from the equator, such as Paraguay, Southern United States, and Madagascar. In Brazil, according to Peckolt, the bitter varieties are not cultivated below lat. 26° S., the sweet varieties extending as far as 30° S.

The plant thrives best in regions of comparatively slight rainfall and requires only 14 to 16 in. of rain per annum. In countries where the rainfall is heavy, it is necessary to select well-drained, light soils to prevent water-logging, which is fatal to the plant. Sufficient moisture is necessary to start the growth of the plant, but once it has become established it will withstand prolonged and extreme drought without injury, and the crop is never a total failure through want of rain.

Although cassava is sometimes cultivated at an altitude of 2,500 to 3,000 ft., the plant matures earlier and gives heavier yields in the valleys. Better results, too, are obtained in regions near the coast than inland.

Sheltered situations should be chosen for the plantation, as the stems are brittle and the plant suffers severely in strong winds.

Soil

The best soil for cassava is a rich, light, sandy loam. Recently cleared forest-land is preferred by the natives in most parts of the tropics, as it is rich in plant food and the crop can be grown on it continuously for several years with good yields. Many growers prefer a soil possessing a hard-pan, as in such cases the roots keep near the surface and are easier to dig. As already mentioned, the plant is drought-resisting and will give good results on very dry sandy soil on which no other foodstuff can be grown successfully. Swampy soils should be avoided and also heavy black soils excessively rich in humus; in the latter case the plant makes much top growth and the roots are small. Heavy clay soils are also unsuitable, as they give low yields and the roots are difficult to dig.

Propagation and Planting

The cassava plant is always propagated commercially by means of stem cuttings. In some varieties seeds are never or rarely formed, but even when available they should never be used, as the plants raised from them always give very low yields of roots. Only the middle portions of well-matured, vigorous stems should be used

for propagation, the basal, woody part and the extremities of the branches being discarded.

If the climatic conditions are favourable and the land has already been prepared for planting, the cuttings may be taken from the standing crop as soon as the roots are mature; but if there is any possibility of frost, the stems must be stored carefully to prevent injury. In the latter case the stems are usually kept through the winter in whatever length they happen to come from the field, but it is best to cut them off about 6 in. above the soil and trim off the immature branches and leaves, which if left on would tend to cause fermentation and decay. The stems should be cut as late as possible to allow the roots to mature fully but before there is any chance of their being damaged by frost. They may be stored, five or six layers deep, in trenches, much as sugar-cane is stored, and covered with soil, in which case the ground should be well drained and dry, as excess of moisture will cause decay. Sometimes the stems are packed upright in trenches about 18 in. deep and 3 to 4 ft. wide and covered with straw or litter kept in place by a little soil; or they may be stored upright in low, wooden sheds and covered in a similar way with straw, the outer sides of the shed being well banked up with soil. Whatever method of storing is adopted, care must be taken to see that the stems are not wet when stored; they must not be left exposed to the air too long after cutting and thus allowed to become dry; the covering should be light at first to enable the excess of moisture to escape, more protection should be added as the weather becomes colder, and, finally, the covering must be of such a nature as to prevent rain from penetrating to the stems.

The cuttings should not be made until they are required for planting. Their length varies in different countries; some natives use pieces 10 to 20 in. long, but the usual length on well-conducted estates is from 4 to 8 in., each cutting possessing two or three buds. It is of course essential to use only living stems which are in good condition. Such may be distinguished by their plump appearance, fresh-looking bark, sound pith, and plump buds; any

stems which appear shrivelled and are of bleached or darkened colour, with discoloured or dried pith and shrunken buds, should be rejected. The ends of the cuttings must be cut cleanly. This may be done with a sharp machete or heavy cane knife, or by pushing the stem along a saw fixed firmly to a block, with the teeth uppermost.

The time of planting depends entirely on the climate. If the dry and wet seasons are sharply differentiated, the cuttings should be put in at the beginning of the rainy season, except where the rainfall is very heavy, when it is better to defer planting to near its close. If the rainfall is fairly evenly distributed or the land is irrigated, planting may take place at any time during the year; while in countries where there is an alternation of cold and warm seasons, it should take place as early as possible in the spring, after all chance of frost is past and when there is no fear of the soil remaining water-logged.

In many countries the cuttings are inserted two or three together, at an angle of about 45°, on mounds about 15 to 18 in. high, and sunk for about two-thirds of their length. In the West Indies they are planted in a similar way on ridges or banks. An experiment recently conducted in St. Vincent, however, indicated that better results may be obtained by planting on the level, the yield of fresh roots per acre being 17,570 lb. by the latter method as compared with 14,054 lb. when planted on banks. Whether the cuttings are planted on mounds or on the level, it is preferable to insert them singly, as if strong, healthy cuttings are employed the yield of roots will be as high as, or higher than, when two or three are planted together, and if any selection work is to be done it can be carried out more accurately. Tracy (*Farmers' Bulletin* No. 167, 1903, *U.S. Dept. Agric.*) recommends planting the cuttings singly in furrows cut with a plough and covering them with 2 to 4 in. of soil, much as in the case of the ordinary potato.

The usual distance of planting is about 4 ft. in all directions, but the actual spacing depends on the character of the soil—the distance being increased on rich soils and decreased on poorer ones—and to some extent on the

vigour of the variety planted. In some countries the rows are 4 to 5 ft. apart and the plants at intervals of 2 ft. or 2 ft. 6 in. in the rows.

In order to ensure a regular stand in the field the cuttings are sometimes sprouted in specially prepared beds and then planted out. This method is useful in the case of stems of doubtful vitality, but great care must be exercised when planting out to prevent the young shoots from being injured or broken off.

Preparation of the Soil and Manuring

Before planting, the soil must be brought into a fine state of tilth. This may be done by ploughing and harrowing. It is advisable not to plough too deeply, so that the roots may keep nearer the surface and be easier to dig.

Newly cleared land will not, as a rule, require manuring, but land which has been under cultivation must be enriched by this means. It is usually stated that cassava is a very exhausting crop, but this view appears to be based on observations made in countries where the natives raise two, three, or more crops on newly cleared land without making any attempt to replace the constituents removed by the roots, and then allow the land to return to grass or bush, which as a matter of fact is a very common practice. Almost any crop grown in this way would cause a soil to deteriorate rapidly, and Copeland, in discussing catch-crops with coconuts (*The Coconut*, London, 1914), expresses the opinion, based on personal observation, that the soil does not deteriorate as rapidly under cassava as it does under rice. Tracy also states that cassava is one of the crops least exhausting to the soil.

Potash is the chief food constituent taken up by the cassava roots, and as potash salts favour the formation of starch and sugar it is essential that this constituent be present in sufficient quantity. Large quantities of available nitrogen in the soil induce an excessive growth of stems and leaves, without a corresponding increase in the yield of roots. If a leguminous crop has preceded cassava, a practice which is much in favour in the United

States, nitrogenous manure will not be necessary, and a mixture consisting of 200 lb. of kainit and 300 lb. of superphosphate per acre may be used. The exact amount applied will depend on the nature of the soil; more should be used on poor soils, whilst on calcareous soils the amount of superphosphate may be less. If nitrogen is to be added, it may be applied conveniently in the form of nitrate of soda at the rate of 250 lb. per acre. The potassic and phosphatic manures should be added before the crop is planted and the nitrogenous manure just after growth has commenced. If chemical manures are not available, about 8 to 10 tons of farmyard manure per acre, mixed if possible with wood ashes, may be used.

Maintenance of the Plantation

About eight to fifteen days after planting, the young shoots begin to appear, and, as already mentioned, the plants need a fairly liberal supply of water until they become well established, which should be afforded by irrigation if necessary. During the growth of the plant the soil should be hoed occasionally to ensure the presence of a fine mulch which is particularly necessary on very dry sandy soils in order to conserve the soil moisture. The plants must be kept clear of weeds until they have become well developed, after which the shade produced will serve to keep the weeds in check. Towards the end of the third month the weaker shoots are removed, leaving only two or three of the most vigorous.

It is the usual practice in many countries to draw the soil up round the base of the plant, as in the case of the ordinary potato. This is necessary where there is any danger of the roots becoming exposed through surface wash; but, as Tracy points out, the roots sometimes meet between the rows, and in such cases they are liable to be injured when the plants are earthed-up. The time of earthing-up depends on the rate of growth of the particular variety. In very early maturing races, as in those grown in Java, the plants are earthed-up about three or four months after planting; but, as a rule, this should be done

during the fifth or sixth month, and again three or four months later.

Cassava as a Catch-crop

Cassava is frequently grown as a temporary shade plant in young cocoa and coffee plantations. It has also been recommended for planting on rubber estates, for besides being a source of revenue until the rubber comes into bearing, the deep digging necessary to remove the roots improves the condition of the soil. In Trinidad it has been grown successfully with limes, plants spaced 4 ft. by 4 ft. yielding 5·63 tons of roots per acre in ten or eleven months from the time of planting. Copeland regards cassava as the best catch-crop for planting with coconuts until the latter begin to bear, provided the conditions are suited to it.

It is almost unnecessary to add that when cassava is grown as a catch-crop, it is essential that the fertility of the soil be maintained by proper manuring, so that the main crop is not adversely affected.

Rotation

Although several crops of cassava can be raised in succession on rich, newly cleared land, a proper system of rotation must be practised sooner or later to prevent deterioration of the soil. In West Africa a system of rotation sometimes practised is to grow ground nuts or some other leguminous crop the first year, two crops of a cereal, such as sorghum or maize, the second year, and then to raise one or two crops of cassava which may occupy the ground for two or three years; occasionally a crop of beans and a crop of sweet potatoes or yams are interpolated in the rotation between the maize and the cassava. In countries where the sugar-cane is cultivated, cassava may enter into the system of rotation with advantage. Hubert and Dupré (*Le Manioc*, Paris, 1910) refer to a system of this kind which is followed in certain countries. Sugar-cane is grown for six years, and at the close of the sixth year cassava is planted together with an intercalary crop, generally maize.

The latter is reaped in the seventh year, and the cassava in the eighth year, when a leguminous crop is sown. In the ninth year the rotation is resumed. The cultivation of the cassava with its surface-rooting habit mellows the soil, and at the same time the crop benefits from the manure which has been applied to the sugar-cane as well as from the humus derived from the leaves and waste of the cane. In the Southern United States cassava commonly follows velvet beans or cow peas. The latter crop matures in a shorter time, and is consequently more suitable where the land has been occupied with oats or some other crop during the spring and early summer.

Harvesting and Yields

The time of harvesting depends on the habit of the variety, on the climatic conditions, and on the use to which the roots are to be put. If required for the preparation of starch or tapioca, the roots must be harvested when they contain the maximum amount of starch. Some varieties mature in as little as seven or nine months, others take twelve or fifteen months or even longer to attain their full growth, and consequently no hard and fast rule can be laid down. It has been shown, however, that no advantage is derived by allowing the roots to remain in the ground after they have become mature; they may continue to increase in size, but they become more fibrous and woody and so are less suitable for the manufacture of starch. As the roots do not keep well after being removed from the soil, except with very careful treatment, they are only dug as required when used for food. If frosts are likely to occur, an early maturing variety must be chosen, so that the roots can be dug before the cold weather sets in.

Owing to the size of the roots they have to be removed by hand. In very light soils this can be done without the use of tools by simply grasping the base of the stem with the hands and pulling the roots. Much labour and time can be saved, however, by the use of some simple tool, which is always necessary on heavier soils. Some-

times an ordinary grubbing hoe is used, but perhaps the most convenient tool consists of a V-shaped hook 5 or 6 in. in length, one arm of which is fixed to a wooden pole, 8 ft. in length and 2 in. in diameter, at a distance of about 2 ft. from the end. To lift the roots the hook is placed under the point of attachment of the roots to the stem and the whole cluster then levered up. To prevent the end of the lifter sinking in the soil, a flat piece of iron or an old spade is sometimes fixed to the short end, and this is also useful for any actual digging which may be necessary. The work is much facilitated if one or two men precede the diggers and cut down the stems to within 6 in. of the soil.

The yield of roots varies considerably in different countries, and depends not only on the variety grown but also on the character of the soil, the amount of cultivation which has been given, and the vigour of the original cuttings. On poor soils the yield may not exceed 2 or 2½ tons of fresh roots per acre, but on a particularly good soil as much as 15 tons per acre has been obtained in the United States. Much higher yields than this have been reported, but as a rule these are estimates obtained from the weight of a few roots and cannot be accepted as representative of actual practice. On the whole 8 tons of fresh roots may be considered a good average yield.

No attempt will be made to recommend any particular varieties for cultivation, as the yield of one and the same variety varies in different localities and on different soils, and it is necessary to carry out careful tests of a series of varieties before the best for any given place and purpose can be correctly ascertained. As a rule the bitter varieties give a higher yield of roots than the sweet varieties, and are therefore preferred for the production of starch, but under the conditions obtaining in the United States sweet cassava has given the best results for this purpose. Not only does the yield of tubers vary in the different varieties, but also the starch content and the time of maturity, as is shown in the following table, which gives the results obtained in a series of experiments carried out a few years ago at the Hope Experiment Station, Jamaica.

Variety.	Yield of roots (tons per acre).			Quantity of starch in the roots (lb. per acre).		
	At 12 months.	At 15 months.	At 21 months.	At 12 months.	At 15 months.	At 21 months.
Blue Top	8·25	14·2	21·9	5,636	9,733	15,818
Black Stick	6·5	6·5	18·0	4,878	5,197	15,433
Smalling	7·5	11·1	19·3	5,494	8,553	13,883
Mullings	5·75	11·1	18·0	4,160	8,180	13,277
Long Leaf Blue Bud .	9·0	15·4	15·4	6,552	12,857	13,187
White Top . . .	10·5	11·0	11·6	7,902	7,638	8,753
Luana Sweet . . .	6·75	8·1	9·0	5,322	6,540	7,102
Rodney	7·5	9·7	10·3	5,337	6,931	6,547

Pests and Diseases

Cassava as a rule suffers comparatively little damage from the attack of insect pests, due no doubt to the presence of latex in the plant, while fungoid diseases are still less important.

The most serious damage done to the plant by insect pests in Central and Southern America is due to the attack of leaf-cutting or parasol ants (*Atta* spp.). These sometimes entirely denude a plantation, cutting out pieces of the leaf about the size of a sixpence and carrying them away to the underground nests, where they are kneaded into a sponge-like mass on which a fungus, the true food of the ant, grows. The best method of dealing with the pest is to inject a poisonous vapour into one of the entrances to the nest after having carefully sealed up all the other entrances. Carbon disulphide has been recommended for this purpose, but liquid sulphurous anhydride gave better results in some experiments recently conducted in French Guiana. The fumes of burning sulphur and arsenic, applied by means of an apparatus such as the Universal White Ant Exterminator, which is used against termites on many tropical estates, should also prove effective.

The bud maggot, the larva of a fly (*Lonchaea* sp.), is the worst pest recorded in Trinidad and is also said to be injurious in Cuba. It bores into the young shoots and destroys the growing bud, causing the stem to send out numerous small branches, which in turn may become affected, the whole growth of the plant being checked in severe attacks. The most satisfactory method of controlling the insect is to cut off and burn all affected shoots.

Crickets and locusts sometimes cause damage to the young shoots and leaves. They can be combated by placing poisoned bait on the ground.

Among other insect pests of cassava which have been recorded from various countries, mention may be made of the cassava hawk-moth (*Erinnys ello*, Linn.), which occurs in the West Indies; *Prodenia litura*, Fabr., recorded as a pest of cassava in Réunion, the caterpillar of which also attacks many other cultivated plants, including cotton (see this BULLETIN, 1912, **10**, 584); *Mytilaspis dispar*, which is allied to the cochineal insect and sometimes completely covers the stems and branches of the plant in Madagascar, especially on bad soils; species of thrips, fairly widespread in the West Indies, but seldom causing much damage; and a longicorn beetle, *Lagochirus obsoletus*, which is of some importance in Cuba, boring into the stems of the growing plants.

Wild pigs and boars sometimes do considerable damage by tearing up and eating the roots, especially on parts of a plantation near the uncleared forest. They are usually captured by means of pits covered with brushwood.

Of fungoid diseases, "leaf-spot," caused by species of *Cercospora*, is found wherever cassava is grown. In Trinidad two types are found: a white leaf-spot, which does but little damage, and a larger brown leaf-spot, ¼ in. to ½ in. in diameter, which causes many leaves to fall prematurely. In the United States the fungus is said to attack only mature leaves as a rule and does little harm. If the disease, however, is found to cause serious damage the plants should be sprayed with a sulphur compound, such as lime-sulphur solution or sulphide of potassium.

Another widespread disease is *Gloeosporium manihoti*, which attacks the leaf stalk chiefly, causing the leaf to wilt, and sometimes attacks the stem. It may be controlled by means of a sulphur spray or Bordeaux mixture, but it can be almost entirely prevented by using cuttings from non-infected fields only.

Diseases due to bacteria have been recorded from Brazil and German East Africa, whilst a root rot of bacterial origin has been reported from Malaya.

Utilisation

The greater part of the cassava produced is utilised as a foodstuff. In some parts the roots are eaten raw, but this is only possible in the case of certain sweet varieties, and even with these there is a danger of ill-effects being produced through hydrocyanic acid poisoning. In most cases the roots are first subjected to heating, which enables them to be eaten without danger. The roots, after being peeled and washed, are sometimes boiled or fried in various ways, but, as a rule, they are first converted into meal, flour, or farine.

In the following pages the composition of the roots and the preparation of the various cassava products are dealt with, together with an account of their industrial applications, and their utilisation as a food for live-stock.

Composition of the Roots

Cassava roots are essentially a carbohydrate food, containing only a small proportion of proteins and fat. The percentage composition varies considerably in different varieties and according to the age of the roots. The following figures, however, may be taken as representing the average; a typical analysis of potatoes is given for comparison.

	Cassava roots.		Potatoes.	
	Fresh.	Dry.	Fresh.	Dry.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	70·25	—	75·80	—
Proteins	1·12	3·76	2·08	8·59
Fat	0·41	1·38	0·20	0·83
Starch	21·45	72·07	} 19·90	82·23
Sugar	5·13	17·25		
Fibre	1·11	3·73	1·10	4·55
Ash	0·54	1·81	0·92	3·80

Cousins has determined the starch content of a number of bitter and of sweet varieties of cassava grown at the Hope Experiment Station, Jamaica, the average results calculated from his figures being as follows;

	Bitter varieties.		Sweet varieties.	
	Moisture.	Starch.	Moisture.	Starch.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
After twelve months' growth:				
Fresh	58·4	32·9	58·4	31·8
Dry	—	79·1	—	76·4
After fifteen months' growth:				
Fresh	60·9	32·5	61·0	32·6
Dry	—	83·1	—	83 6
After twenty-one months' growth:				
Fresh	59·4	34·2	60·2	34·7
Dry	—	84·2	—	87·3

It will be seen that after twelve months' growth the bitter varieties on the whole gave a higher percentage of starch, but that after a further nine months the position was reversed.

Hydrocyanic Acid in Cassava.—The presence of hydrocyanic acid (prussic acid) in cassava roots was first recorded by Boutron-Charlard in 1836. As a result of investigations conducted at the Imperial Institute (this BULLETIN, 1903, **1**, 15), it was ascertained that the acid does not wholly occur as such in the root, but is generated by the action of an enzyme on a glucoside. The latter was subsequently ascertained to be phaseolunatin, which also occurs in certain varieties of *Phaseolus lunatus* beans (Dunstan, Henry & Auld, *Proc. Roy. Soc.*, 1906, B, **78**, 152). Owing to the great importance of the subject most of the investigations on the occurrence of hydrocyanic acid in cassava have been concerned with determining the amount yielded by sweet and bitter varieties respectively. Francis in 1870 was the first to show that hydrocyanic acid is yielded by sweet cassava roots. He found that the average amount furnished by the whole root was 0·0168 per cent., the highest being 0·0238 and the lowest 0·0113 per cent. Carmody, in a paper published in the *Lancet* in 1900, showed that although sweet cassava may yield as much hydrocyanic acid as the bitter form, there is a difference in the distribution of the acid in the roots in the two cases. In the sweet variety he found that most of the hydrocyanic acid was in the skin and outer cortical layer, whilst in bitter cassava it was more evenly distributed through the root. As it is the almost universal practice to peel the sweet cassava roots

before eating them, the fact just mentioned explains why cases of poisoning by this variety are so rare. Typical examples of Carmody's results are shown below:

Sweet cassava.		Bitter cassava.	
Inner part.	Skin and outer cortical layer.	Inner part.	Skin and outer cortical layer.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
0·006	0·033	0·031	0·024
0·003	0·014	0·021	0·025
0·015	0·033	0·014	0·013
0·008	0·031	0·017	0·019
0·011	0·020	0·016	0·024
0·004	0·024	0·013	0·016
0·010	0·030	0·032	0·035

These results have been confirmed in the main by subsequent observers. Cousins, for example (*Bull. Agric. Dept., Jamaica*, 1907, **5**, 78), found that twenty-four out of twenty-six Colombian varieties of sweet cassava grown in Jamaica had most of the hydrocyanic acid in the cortical part of the root. The remaining two, although sweet to the taste and found by actual experiment on four persons to be non-poisonous, contained 0·0062 and 0·0024 per cent. of hydrocyanic acid in the cortex and 0·0114 and 0·0130 per cent. in the interior respectively.

Moore (*Bulletin* No. 106, 1906, *Bur. Chem., U.S. Dept. Agric.*), however, found that in specimens of both bitter and sweet cassava grown in Florida, most of the hydrocyanic acid was in the skin and cortex. His results were as follows:

	Sweet cassava (Florida Sweet).		Bitter cassava (White Top).	
	Proportion of part to whole root.	Hydrocyanic acid.	Proportion of part to whole root.	Hydrocyanic acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Skin . . .	1	0·068	1	0·076
Cortex . .	25	0·054	12·5	0·023
Inner part . .	74	0·002	86·5	0·0005

Moore states that the proportion of hydrocyanic acid present varies not only with the variety but also with the size of the root. The smaller roots, containing a relatively

larger proportion of skin and cortex, yield more acid than larger ones, whilst the lower part of tapering roots contain more than the upper large part. He found that the lower part of a tapering root of a bitter variety (White Top) contained 0·039 per cent. of hydrocyanic acid, the large upper part containing 0·028 per cent., whilst a small root of a sweet variety (Florida Sweet) contained 0·005 per cent., the average-sized root of that variety containing only 0·002 per cent.

Collens (*Bulletin Dept. Agric. Trinidad and Tobago*, 1915, **14**, 54) obtained somewhat similar results in the case of bitter cassava, but in roots of sweet cassava he found that the lower part yielded less acid than the upper. So far the reason for this difference has not been ascertained.

The amount of hydrocyanic acid in cassava may also be increased or diminished when a variety is grown in a new locality. Cousins (*Bulletin Agric. Dept., Jamaica*, 1907, **5**, 78) found that a number of Colombian varieties of sweet cassava when grown for one year in Jamaica yielded on the average 0·0034 per cent. of acid, but after having been grown for five years the yield was 0·0124 per cent.; the increase in this case was mainly in the cortex, which yielded an average of 0·0649 per cent. of acid. The results obtained by Moore in Florida, on the other hand, seemed to indicate that the yield of acid decreased after continued cultivation.

The fact that the yield of acid varies when one and the same variety is grown in different localities, was also demonstrated by Moore, who obtained the following results among others:

Variety.	Miami, Florida.	Biloxi, Missouri.	Cuba.
	Per cent.	*Per cent.*	*Per cent.*
1. Helada	0·010	0·003	0·015
2. "	0·001	0·001	0·016
3. Negrita	0·005	0·007	0·007
4. "	0·002	0·003	0·022
5. Pie de Perdiz	0·009	0·001	0·008
6. Mantera	0·008	0·002	0·040

Hydrocyanic acid is yielded by all parts of the cassava plant, as is shown by the following results given by Collens in the paper already referred to:

	Sweet. Per cent.	Bitter. Per cent.
Top: Full-grown green leaves	0·0162	0·041
Green stem where leaves arise	0·0144	0·024
Woody mature stem: Green cortex or peel	0·043	0·113
Inner woody portion	0·0072	0·0027
Pith	0·019	0·076
Roots, freshly dug: Peel	0·0147	0·055
Inner part	0·0048	0·053

Preparation of Cassava Meal and Flour

In West Africa the roots, as soon as they are dug, are washed and peeled and then cut into halves longitudinally. The more fibrous central part is removed and the remainder cut up into pieces 3 or 4 in. long. These are spread out in the sun until completely dried, in which condition they keep well for several months. When required for use the dried material is pounded into meal in a wooden mortar, and then sifted to remove any fibre that may be present. Cassava flour is prepared in a somewhat similar way, as a domestic product in Florida and other parts of the United States. The roots are peeled, chopped into thin slices or grated, dried in the sun, and then ground into a fine powder. This flour is used as a substitute for wheat flour in making bread and puddings, but is inferior in general nutritive properties. The percentage composition of two such cassava flours according to Wiley (*Bulletin* No. 58, 1900, *Div. Chem., U.S. Dept. Agric.*) was as follows:

	Cassava flour. 1.	Cassava flour. 2.
Moisture	10·56	11·86
Ash	1·86	1·13
Petroleum ether extract (fat)	1·50	0·86
Ether extract (resins and organic acids)	0·64	0·43
Alcohol extract (amides, sugar, and glucosides)	13·69	4·50
Dextrin, gum, etc. (by difference)	2·85	5·63
Crude fibre	2·96	4·15
Proteins	1·31	1·31
Starch	64·63	70·13

A sample of dried and grated cassava, described as "garri," from the Southern Provinces, Nigeria, examined at the Imperial Institute a few years ago (see this BULLETIN, 1912, **10**, 565) was found to have the following percentage composition:

Moisture	11·4	Carbohydrates (by difference)	82·1
Crude proteins	2·1	Fibre	1·8
Fat	1·1	Ash	1·6

Preparation of Farine

The term farine is applied in the West Indies to a product obtained by grating the fresh root, draining away the juice from the wet pulp and then heating the residue. It is sometimes spoken of as cassava meal, but it is better to restrict this term to the product obtained by the dry method referred to in the preceding section.

Farine is prepared in the West Indies from both the bitter and the sweet cassava, but generally from the former. The freshly dug roots are scraped until the yellowish underskin is removed, and then washed in clean water. They are next grated as finely as possible. A simple machine for effecting this consists of a wooden wheel 2½ to 3 ft. in diameter, and 8 or 9 in. wide, on which is fixed a perforated sheet of iron or tin, the rough edges of the perforations projecting outwards. The wheel may be worked by hand or by means of a treadle, the roots being pressed against the grater by means of a piece of wood, resting on a projecting table, and the grated root being collected in a box below. The draining of the pulp may be effected by placing it in a coarse sack, upon which weights are placed and added to from time to time. Sometimes a plank having one end attached to a post or tree is laid over the sack and weights attached to its free end; by this method the juice can be expressed from 100 lb. of grated cassava in 12 hours by a weight of 56 lb. Whichever method is employed arrangements are made to collect the juice which is expressed.

A better method of removing the juice is by means of a "coulef." This is a cylindrical, closely woven basket about 4 ft. long and 4 to 6 in. in diameter. The wet pulp is packed tightly in the coulef, which is hung up by a ring in its upper end. Weights are attached to a ring at its lower, closed end, and as the basket stretches the juice is forced out and caught in a receptacle below. The drained pulp is rubbed through a coarse sieve to remove fibrous portions of the root, or any which may be incompletely grated, and then dried on a circular iron plate over a wood fire. The heat must be kept uniform and the farine con-

stantly stirred. The temperature should be low at first, but may be raised as drying proceeds, care being taken to prevent scorching. Thorough drying takes about 3 to 4 hours.

The juice which is expressed from the wet pulp contains a certain amount of starch, which is often collected by decanting off the clear liquor and is utilised locally. The liquor is evaporated by heat until it has the consistency of syrup and is then known as "cassareep," which is used, in conjunction with capsicums, in preparing the well-known "pepper-pot" of the West Indies. The juice as it comes from the pulp will contain a certain amount of hydrocyanic acid (Collens records 0·037 per cent. from that expressed from bitter cassava), but this is driven off during the evaporation.

In Brazil a coarser kind of farine is made, known as "couac." In West Africa a similar product is made, which is sometimes called "garri," but it may be mentioned that this term is also applied in West Africa to dried and grated cassava (see p. 598).

Preparation of Starch and Tapioca

Cassava starch, sometimes known as Brazilian arrowroot, is produced on a considerable scale in Brazil, United States, East Indies, West Africa, and elsewhere. The chief centres for the production of tapioca are Malaya, Dutch East Indies, and Brazil.

The processes of manufacturing these two products are identical up to a certain point. They consist essentially in grating the cleaned roots sufficiently finely to break the cell walls and so liberate the starch, which is subsequently separated from the fibre and collected in tanks of water. For industrial purposes the starch is then dried, but if tapioca is to be made the wet starch is placed on hot iron plates, which cause the grains to gelatinise and adhere together in lumps.

The machinery required depends on the quantity of roots available. On a small scale all the work can be carried out by hand, but where large quantities are dealt with power-driven machinery must be used. In either

case the first essential to success is a plentiful supply of pure, soft water, and the roots must be freshly dug.

There are several types of machines employed for the preparation of cassava starch, and, speaking generally, all the machinery used in a potato starch factory can be employed for cassava although slight modifications in the character of the grating or pulping machine and of the sieves is necessary, cassava roots being more fibrous than potatoes and the starch grains smaller.

The roots arrive at the factory in all sizes. The larger ones are usually peeled, cut in pieces, and put into a cleaning tank. The smaller roots are placed at once in a washing machine, from which they are transferred automatically to a hopper leading to a pulping machine running at a high speed. This may consist of a cylinder covered with perforated sheet iron or a drum fitted with finely cut saws. The pulp is carried away in a stream of water to the starch separator, but is sometimes further treated in a mill to complete the disintegration of the cells and ensure the maximum yield of starch. The sieve for separating the starch from the fibre may consist of an oscillating frame covered with fine silk cloth on which water at high pressure is sprayed, or sometimes a horizontally revolving cylinder, covered with fine cloth and kept sprayed with water, is used. As a rule two or three sieves of different mesh are used to facilitate the process. The starch and water from the sieves are run into large settling tanks. The clear water is run off and fresh water added, the starch being stirred with paddles either by hand or mechanically. This process is repeated six or seven times until all foreign matter has been eliminated; the starch is then allowed to settle in tanks of water.

In a process devised by Dr. G. Archbold (*Journ. Soc. Chem. Ind.*, 1903, **22**, 65) quite a different method of separating and washing the starch is employed. After grating and macerating the roots in the usual way, the pulp is carried down a pipe to a point near the apex of an inverted metal cone. A current of water is forced upwards through the cone in sufficient strength to carry the starch grains through a wire gauze strainer fixed across the cone near the wide,

upper end. The fibrous part of the pulp is left in the cone and is discharged through a door when all the starch has been removed. The water containing the starch grains, together with a certain amount of impurity, passes downwards through a pipe into another inverted cone, but here the upward flow of water is only sufficient to carry over the lighter impurities, the starch grains being left behind. The starch milk is then mixed with dilute alkali, which assists in the purification of the starch. It is next carried on to an oscillating sieve, which removes any particles of fibre present, and is finally washed in cones similar to that last mentioned. It is claimed that by this process practically the whole of the starch in the roots is recovered, or 25 per cent. more than by using a modification of the machinery usually employed for the preparation of potato starch.

In a process which has been patented recently (English Patent 530, January 8, 1914), the roots are reduced to fragments, and dried rapidly at a temperature below the gelatinising point of the starch, until they become brittle. They are next ground to a fine powder which will pass an 80- or 100-mesh sieve. The powder is then moistened and ground into a paste from which the starch is separated in the usual way.

Up to this point the manufacture of industrial starch and of tapioca are the same. If the former is to be made, the wet starch in the settling tanks is dried in a vacuum drier or in specially constructed kilns, but great care has to be exercised in applying heat, as if the temperature is too high at the commencement the starch is liable to gelatinise. Before the starch is packed in barrels for shipment it is usually stacked in heaps under cover in order that the moisture remaining in it, which usually amounts to about 13 or 14 per cent., may become uniformly distributed.

For details as to the machinery required for the preparation of cassava starch, reference may be made to *Le Manioc*, by Paul Hubert and Emile Dupré (Paris: Dunod et Pinat, 1910); *The Manufacture of Starch from Potatoes and Cassava*, by H. W. Wiley (*Bulletin* No. 58, 1900, *Div. Chem.*, *U.S. Dept. Agric.*); and *The Spice Mill* (1912, **25**, 482).

In the manufacture of tapioca the wet starch is rubbed through a coarse sieve or broken up into small pieces by some other means, and placed on a large, slightly concave, iron plate or pan, heated by means of a wood fire, or, in modern factories, by steam under pressure. The granules are stirred with a flat, four-pronged fork, and after a few minutes the starch grains gelatinise and the granules take on the semi-vitreous appearance of ordinary tapioca. Occasionally the granules are treated in steam-heated, horizontally revolving cylinders. The granules, which usually vary considerably in size, are next dried thoroughly, when they are ready for shipment. Before they are placed on the market, however, they are broken up in special mills and graded according to size into bullet, medium, and seed. These grades are known collectively as pearl tapioca. Flake tapioca is made by placing a thin layer of wet starch on the hot plate and then stirring.

Samples of cassava starch from the Gold Coast and Natal have been examined at the Imperial Institute with the following results (see this BULLETIN, 1912, **10**, 563, 564):

	From Gold Coast.	From Natal.
	Per cent.	*Per cent.*
Starch	77·68	86·07
Moisture	21·68	13·84
Ash	0·06	0·09

Balland (*Journ. Pharm. et Chim.*, 1903) gives a number of analyses of cassava starch and tapioca from various sources from which the following are selected:

	Starch.				Tapioca.		
	Cochin China.	Madagascar.	Réunion.	Guatemala.	Martinique.	New Caledonia.	Réunion.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	15·80	15·80	14·50	13·70	9·30	13·60	10·60
Crude proteins	0·44	0·84	0·44	0·46	0·30	0·30	1·68
Fat	0·22	0·20	0·10	0·30	0·45	0·25	0·40
Carbohydrates	83·84	82·96	84·66	84·09	88·95	85·60	86·82
Fibre	0·00	0·00	0·00	0·75	0·00	0·00	0·00
Ash	0·20	0·20	0·30	0·70	1·00	0·20	0·50

Dried Cassava and Cassava Chips

Cassava roots very quickly decay after removal from the ground, and if they are to be utilised for the production of starch, alcohol, or glucose in Europe they have

to be thoroughly dried before shipment. The roots are either cut into slices or ground into meal and dried in the sun, where the climate is favourable, or in special kilns. Cocoa-drying houses and vacuum driers have proved successful for this purpose. Rapid drying is essential to success, as otherwise the product becomes discoloured and consequently realises lower prices.

The composition of dried cassava roots from Java, as imported into Germany, is shown in the following table:

	Fresh. *Per cent.*	Dried. *Per cent.*
Moisture	11·28	—
Crude proteins	1·35	1·52
Fat	0·27	0·30
Starch, etc.	83·27	93·86
Crude fibre	1·98	2·23
Ash	1·85	2·09

Alcohol from Cassava

Of all materials used in the production of alcohol, cassava is one of the richest in fermentable substances. In the fresh state, high-grade roots contain about 30 per cent. of starch and 5 per cent. of sugar. Even if the average content of fermentable matter be taken as 25 per cent., which is undoubtedly low for cassava roots, this amount is much greater than that of potatoes or even of sweet potatoes and yams. The dry roots contain about 80 per cent. of fermentable substances, and are almost as valuable as a source of alcohol, weight for weight, as rice.

Experiments on the yield of alcohol obtainable from cassava have been conducted recently by A. E. Collens at the Government Laboratory, Trinidad. Only small quantities of roots were employed and, from the results, the calculated yield of 94 per cent. alcohol per ton of material was as follows:

	Yield expressed on material as used. *Gallons per ton.*	Yield expressed on dried material. *Gallons per ton.*
Freshly dug roots, pulped and boiled, treated with malt	18·9	75·6
Roots purchased in open market, grated and boiled, treated with taka-diastase	32·6	81·5

Prudhomme has also conducted experiments on this subject, and his results are as follows:

	Yield of crude alcohol. *Gallons per ton.*
Dried and cleaned cassava in pieces	90
Dried cassava in thin slices	89
Dried cassava, with cortex, in rings	87

The crude alcohol obtained from cassava is stated to be of only moderate quality. It has an objectionable odour, but the quality may be improved by rejecting the first and last fractions during distillation.

The method of obtaining alcohol from cassava roots does not differ from that used in the case of other similar material, such as potatoes. The starch is first converted into fermentable sugars by treatment with malt, diastase extract, or acid, and yeast is added. By keeping the wash at a proper temperature the sugar is fermented, with the production of alcohol, carbon dioxide, and a small proportion of other substances. The alcohol is then separated by distillation. Special apparatus is required if cassava flour or starch is employed. An outline of the methods used for the manufacture of alcohol from various raw materials has been given in this BULLETIN (1911, **9**, 167). For full details as to the various methods of producing alcohol from cassava products, Hubert and Dupré's book, previously mentioned, may be consulted.

Cassava as a Source of Glucose

Considerable quantities of cassava are used in the manufacture of glucose. Either the pulped roots, dried roots, or the starch may be employed for this purpose. There are several methods of manufacture, which differ in details, but the underlying principle depends on the fact that when starch is boiled with dilute acids it becomes converted into glucose. According to the usual process, cassava pulp is placed in an open vat with water heated by a copper steam coil, and acid is added. The temperature is brought to the boiling point and the starch and much of the fibre are rendered soluble. The material is then run into a closed copper converter and subjected to steam under pressure for ten minutes or so, until the

proper degree of conversion is attained. The liquor is next almost neutralised with sodium carbonate and run through a filter press. The solution of glucose is then filtered through charcoal, concentrated by heating, again run through charcoal, evaporated in a vacuum pan, and the glucose finally cooled and barrelled. By this process glucose can be obtained to the extent of about 30 per cent. of the weight of the fresh root.

Other Industrial Applications of Cassava Starch

Cassava starch can be utilised for almost all the purposes for which other starches are employed. In addition to its employment in the manufacture of alcohol and glucose, it is used for laundry purposes, for sizing yarns and fabrics, and for the manufacture of dextrin or British gum.

For laundry purposes cassava starch is inferior to rice starch, but is said to be much better than either maize starch or potato starch, giving a smoother surface and a finer gloss.

Cassava starch is stated to be inferior to other kinds of starch for sizing cotton yarn, as it yields a paste of somewhat feeble adhesive properties. For medium and heavy sizing it may be mixed with some other material with stronger adhesive power, such as wheat flour or maize starch. Tracy (*Farmers' Bulletin* No. 167, 1903, *U.S. Dept. Agric.*) states that the whole of the output of the cassava starch factories existing in Florida at the time he wrote was sold to cotton factories where it was used in making sizing for various classes of goods.

Cassava as a Feeding-stuff for Live-stock

Fresh Roots.—A very large proportion of the cassava grown in the United States is fed to live-stock. As has been mentioned previously, only sweet cassava is cultivated there, and the roots are fed in a fresh condition to all kinds of animals, including horses, milch cows, fattening cattle, hogs, and poultry (Tracy, *loc. cit.*). Owing to the large proportion of starch contained in the roots, they are usually

fed in combination with bran, middlings, cotton-seed meal, or other nitrogenous feeding-stuffs.

When fed to milch cows, the roots are stated to increase the flow of milk, and to produce a richer colour, which is retained in the butter, whilst the flavour of both the milk and the butter is not affected. Large quantities of the roots can be fed without endangering the health of the animals, some farmers using as much as a 10-quart bucketful twice daily per head. Very successful results have been obtained in the case of fattening cattle by feeding them on a ration containing 15 lb. of cassava roots and 2 lb. of cotton-seed meal. When fed to either milch cows or fattening cattle the roots should be cut or broken into small pieces.

In the case of pigs the animals may be allowed to feed on the standing crop, but it is better to dig the roots first. For growing pigs a nitrogenous food must be added to the diet, but after they have reached a sufficient size they may be fattened exclusively on cassava roots. The pork produced is then very white and of fine flavour. Recent experiments in Belgium and France have shown that the dried roots, either reduced to pulp or fed raw, give excellent results with fattening pigs when fed in combination with pollards and either skimmed milk, mangolds and meat meal, or rice gluten and bone meal.

The fresh roots are readily eaten by poultry. For laying hens it is necessary to mix them with wheat, oats, or some similar nitrogenous food.

Factory Waste.—The residues produced in cassava starch and tapioca factories are largely utilised for feeding live-stock, being used extensively in Malaya as a food for pigs. In the United States the waste is fed to horses, cattle, and pigs, whilst a large number of feeding-stuffs, consisting wholly or in part of cassava residues, are on the European markets.

As the residues, like the roots, form essentially a carbohydrate food, it is necessary to mix them with materials containing fat and proteins, and, should these be poor in lime, phosphate of lime should be added. Few accurate tests of the feeding value of cassava waste have been recorded, but in view of its excellent mechanical condition

and its high nutritive value it should prove a valuable food.

Hansson found that cassava refuse, obtained in the manufacture of starch, when fed to pigs had a beneficial influence on the quality of the pork and on the slaughter weight of the animal. He concluded from his experiments that the particular food tried was only slightly inferior to barley for fattening pigs.

The percentage composition of various feeding-stuffs prepared from cassava waste in Germany is shown in the following table:

	1.		2.		3.		4.	
	Fresh.	Dry.	Fresh.	Dry.	Fresh.	Dry.	Fresh.	Dry.
Moisture	10·93	—	11·68	—	10·3	—	86·56	—
Crude proteins	3·59	4·03	1·25	1·41	1·12	1·25	0·25	1·86
Fat	0·74	0·84	0·21	0·24	0·12	0·13	0·03	0·22
Starch, etc.	75·95	85·27	76·60	86·73	80·25	89·46	12·04	89·58
Crude fibre	6·10	6·84	4·06	4·60	5·62	6·27	0·78	5·81
Ash	2·69	3·02	6·20	7·02	2·59	2·89	0·34	2·53

It will be seen by comparing these figures with the analyses of the fresh roots and of dried cassava on pages 594 and 604 that the residues are slightly poorer in nutritive constituents, and contain a larger proportion of fibre and ash.

Trade in Cassava Products

Little reliable information is available as to the trade in the various cassava products, as the official returns do not clearly differentiate between them, but the following statistics will serve to indicate the magnitude of the industry.

Imports into Consuming Countries

In 1914 the United Kingdom imported 299,097 cwts. of "cassava powder and tapioca," valued at £235,817. Of this quantity 192,254 cwts. came from the Straits Settlements and dependencies, including Labuan, and 95,396 cwts. from Java. In the same year this country also imported 566,528 cwts. of "tapioca flour" (cassava starch) of value £251,883, 424,669 cwts. coming from Java, 96,538 cwts. from

the Netherlands, and 40,411 cwts. from the Straits Settlements.

The imports of cassava products into France in 1913 were as follows:

	Quantity.	Value.	Chief countries of origin.
	Cwts.	£	
Cassava flour[1]	94,660	66,382	East Indies
Dried cassava	395,252	132,552	French Colonies
Crude tapioca	139,125	127,358	East Indies
Crushed tapioca	13,391	13,610	,, ,,

[1] *Including sago and salep (prepared from the roots of an orchid).*

Cassava products are not shown separately in the Hamburg trade returns, but the imports of tapioca and sago into that port in 1913 amounted to 78,673 cwts., valued at £61,328, the greater part of which came from the East Indies.

The total imports of cassava products into the United States in 1914 amounted to 636,650 cwts., valued at £331,378. These came mainly from the Dutch East Indies.

Exports from Producing Countries

British Possessions.—Large quantities of tapioca and cassava starch are exported from the Straits Settlements. The following tables giving the imports and exports from that country in 1914 show that about one-quarter of the total exports of pearl tapioca, one-half the flake tapioca, and most of the cassava starch are derived from other countries:

Pearl Tapioca

Imports.		Exports.	
From	Quantity.	To	Quantity.
	Cwts.		Cwts.
Johore	41,518	United Kingdom	169,660
Kedah	35,816	India	8,580
Negri Sembilan	25,350	Hong Kong	8,907
Pahang	5,184	Canada	25,114
Java	19,329	Australia	70,749
Other countries	940	New Zealand	27,240
		Denmark	26,720
		Germany	31,181
		United States	107,899
		Other countries	32,315
Total quantity	128,137	Total quantity	508,365
Total value	£61,023	Total value	£242,093

Flake Tapioca

Imports.		Exports.	
From	Quantity.	To	Quantity.
	Cwts.		*Cwts.*
Johore	31,338	United Kingdom .	25,587
Pahang	2,432	France . . .	33,730
Negri Sembilan .	3,655	United States . .	7,078
Other countries. .	317	Other countries .	7,319
Total quantity .	37,742	Total quantity .	73,714
Total value . .	£18,803	Total value . .	£35,567

Cassava Starch

Imports.		Exports.	
From	Quantity.	To	Quantity.
	Cwts.		*Cwts*
Kedah	4,909	United Kingdom .	26,006
Perak	8,362	India	23,522
Java	96,264	Hong Kong . .	18,406
Other countries. .	969	Japan	28,527
		Other countries .	19,243
Total quantity .	110,504	Total quantity .	115,704
Total value . .	£42,830	Total value . .	£45,654

The exports of tapioca from the Federated Malay States have decreased considerably in recent years. In 1909 and 1910, 269,837 and 172,637 cwts. respectively were exported, whilst in 1913 and 1914 the quantity was only 58,634 and 58,368 cwts.; the values in the two last-named years were £23,232 and £24,023. The kind of tapioca exported and the countries of destination are not recorded in the official trade returns, but it will be seen from the preceding tables, showing the imports into the Straits Settlements, that both pearl and flake tapioca, as well as cassava starch, are produced in the Federated Malay States, and that most of the exports are shipped via the Straits Settlements.

Statistics of the quantity of cassava products exported from other parts of Malaya (Johore, and the protected State of Kedah) are not available, but an idea of the amount exported overseas, most of which is sent via the Straits Settlements, can be obtained from the foregoing statistical tables.

Dutch Possessions.—The exports of cassava products from Java and Madura in 1913 were as follows:

	Cwts.
Tapioca, flake	206,000
„ pearl	15,400
Cassava starch	1,048,000
Dried roots	508,000
Refuse from factories	278,000

Of the above quantity of cassava starch the United States took 440,000 cwts., the United Kingdom being the next largest consumer, taking about 300,000 cwts. annually. Of the other products the United Kingdom takes 58 per cent. of the total exported.

Cassava products are also exported from the East Coast of Sumatra, the quantity of cassava starch exported in 1912 amounting to 18,660 cwts.

French Possessions.—The chief French Colony producing cassava is Madagascar, which in 1912 exported 22,378 metric tons of dried cassava, valued at £116,928, and 682 metric tons of cassava meal, valued at £6,418. In the same year, 1,544 metric tons of tapioca, of value £33,127, and 329 metric tons of cassava starch, of value £2,476, were exported from Réunion, and 771 metric tons of starch, valued at £7,706, from Indo-China. Most of the produce of the French possessions is exported to France.

Brazil.—Recent statistics relating to the exports of cassava products from Brazil are not available. The quantities exported in 1908 and 1909 were as follows:

	1908. Metric tons.	1909 Metric tons.
Cassava starch	5,458	5,161
Tapioca	248	141

A certain amount of dried cassava is also exported from Brazil.

THE OCCURRENCE AND UTILISATION OF ZINC ORES.—PART I.

THE large amount of zinc now required for military purposes has led to considerable interest being taken in the sources of supply of zinc ore, especially those capable of yielding a high-grade product, and in the location of zinc-smelting works.

In the following pages are given a description of the chief zinc minerals, and a brief account of the more important occurrences in the United Kingdom, the Colonies, and India. In a subsequent number it is proposed to discuss occurrences in foreign countries, together with methods of smelting zinc ore and the utilisation of the metal and its compounds.

The outbreak of war led to a remarkable situation in the British and Colonial zinc markets. In the first place, the demand for the metal, known commercially as spelter, increased enormously, but as most of the British supply of zinc had previously come from Germany and Belgium, the quantity available was considerably reduced. Again, there were enormous quantities of ore awaiting shipment in New South Wales, but most of the British smelters were unable to treat it, as the processes in use were unsuitable for this class of ore. The shortage of spelter was temporarily met by exports from the United States, but as the production is usually only about equal to the consumption in that country, this led to a rapid rise in the price of the metal. The deficiency is now being met by the erection of additional smelteries in the United States and Canada, and by increasing the capacity of the smeltery at Seaton Carew, Durham, for treating ore from New South Wales. Previous to the war, a very large proportion of the zinc ore raised in New South Wales was exported to Germany and Belgium for treatment, as the British smelters usually treat only a high-grade ore. It may be mentioned in this connexion that the output of zinc ore from New South Wales would be sufficient to supply the entire demand of the United Kingdom for metallic zinc.

With a view to relieving the spelter situation and rendering the United Kingdom independent of foreign supplies, it has been proposed to erect large smelting works in this country under Government subsidy, and a special committee has been appointed by the Secretary of State for the Colonies and the President of the Board of Trade to elaborate a scheme.

The following tables give the trade of the United Kingdom in zinc ore and metal and show how important

an adequate supply of the metal is to British industries, even in normal years:

Imports of Crude Zinc, in Cakes, into the United Kingdom

From	1912.		1913.		1914.	
	Tons.	£	Tons.	£	Tons.	£
Germany	54,686	1,429,655	64,179	1,503,023	33,491	730,441
Netherlands	9,992	264,572	13,301	320,091	12,189	284,691
Belgium	57,207	1,495,850	53,500	1,291,011	27,312	615,538
France	5,983	150,879	5,915	144,921	3,183	69,876
United States	4,915	129,223	4,670	116,292	35,068	939,199
Canada	997	19,712	962	18,514	1,319	25,526
Other countries	3,488	84,239	2,477	56,826	3,297	84,536
Total	137,268	3,574,130	145,004	3,450,678	115,859	2,749,807

The imports of crude zinc in the first eleven months of 1915 as compared with the corresponding period of 1913 were as follows:

		1913.	1915.
Quantity	tons	134,271	71,145
Value	£	3,221,455	3,707,371

It will be seen that although not much more than half the quantity was imported in 1915, the value is £485,916 greater than in 1913.

Imports of Zinc Ore into the United Kingdom

From	1912.		1913.		1914.	
	Tons.	£	Tons.	£	Tons.	£
Australia	20,611	113,500	16,772	83,892	78,503	411,586
Italy	13,963	121,191	13,801	106,826	23,280	152,706
Algeria	8,707	62,429	9,302	61,821	6,929	35,662
Germany	5,004	47,742	7,169	58,227	5,190	39,938
France	3,408	31,779	4,337	28,875	3,175	20,362
Spain	8,417	44,512	6,348	27,162	6,474	29,295
Russia	21	270	315	1,443	6,436	36,737
Japan	—	—	1,190	10,020	5,191	44,380
Other countries	7,208	60,206	5,436	39,362	9,073	46,337
Total	67,339	481,629	64,670	417,628	144,251	817,003

Zinc Minerals

Zinc blende, also known as sphalerite, is a sulphide of zinc, ZnS, which is often contaminated with iron sulphide, cadmium, and manganese. Occasionally it contains traces of indium, gallium, and thallium. It often contains silver, but very rarely gold. Most commonly, its colour is brown or black, the mineral being then known

as "Black Jack"; but occasionally yellow, red, and green specimens are found. It crystallises in the cubic system. Its specific gravity and hardness vary from 3·9 to 4·1 and 3·5 to 4 respectively.

Smithsonite is a carbonate of zinc of the formula $ZnCO_3$, being also known as zinc spar, and to the miners as "dry bone." It is sometimes also known as "calamine," but this term is ambiguous, as it has been applied to the silicate as well as the carbonate. Usually the mineral is contaminated with carbonates of iron, cadmium, and manganese. Pure smithsonite is a brittle mineral, white or greyish in colour, having a specific gravity of 4·3 to 4·45 and a hardness of about 5. Its fracture is imperfectly conchoidal and its lustre is vitreous. It crystallises in the rhombohedral system, but well developed crystals are rare, granular and earthy forms being more common.

Hemimorphite is a hydrosilicate of zinc of the formula $3ZnO,SiO_2 + H_2O$. It is a brittle mineral of a whitish colour and has a sub-conchoidal fracture. Its specific gravity varies from 3·4 to 3·5 and its hardness is about 4·5 to 5. It crystallises in the orthorhombic system, but also occurs massive, granular, and in botryoidal and fibrous forms.

Franklinite is a mangano-ferrate of iron, manganese, and zinc, found in large quantities in New Jersey, U.S.A., but rarely elsewhere. The mineral is greyish-black, brittle, and crystallises in the cubic system. Its hardness varies from 5·5 to 6·5 and its specific gravity from 5·07 to 5·22.

Zincite is oxide of zinc, ZnO, usually occurring in massive or granular reddish forms. It commonly contains oxide of manganese as an impurity, and has a specific gravity of 5·4 to 5·7. It occurs associated with franklinite in New Jersey, U.S.A.

Hydrozincite is a carbonate of the formula $3ZnCO_3 + 2H_2O$, usually occurring in earthy chalk-like masses. The only deposits of any importance occur in the provinces of Santander and Guipuzcoa in Spain.

Willemite is a silicate of zinc of the formula $2ZnO,SiO_2$. The only occurrence of any commercial importance is in New Jersey, where it occurs with franklinite.

Of the above ores, zinc blende is the most important, but large quantities of the carbonate and silicate ores are also obtained.

World's Production of Zinc Ores

The production of zinc ore in the British Empire and in foreign countries in recent years is shown in the following table:

	1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Metric tons.	£	*Metric tons.*	£	*Metric tons.*	£
United Kingdom	17,652	82,690	17,704	87,867	17,294	69,502
New South Wales[1]	516,378	1,414,980	520,518	1,766,242	506,660	1,547,987
Canada	2,590	20,846	6,415	44,374	7,889	38,533
India	—	—	—	—	3,934	4,871
Egypt	—	—	1,967	—	3,160	—
Union of S. Africa	28	291	—	—	—	—
Sweden	88,779	315,240	83,558	313,636	50,752	—
Norway[2]	2,240	2,750	40	50	897	—
Germany	699,970	2,466,200	643,598	2,614,850	637,308	—
Belgium	836	4,224	1,167	5,660	1,100	—
France	43,761	206,360	45,929	208,520	46,577	—
Spain	162,140	269,700	175,311	306,827	174,831	—
Austria	32,166	103,005	34,675	120,202	34,225	—
Hungary	106	331	777	2,855	406	—
Russia	9,900	—	11,100	—	—	—
Greece	37,573	132,890	31,070	108,520	51,363	—
Italy	140,269	615,779	149,776	731,451	158,278	—
China[3] Ore	4,780	6,982	7,170	17,177	9,550	—
China[3] Metal	710	11,976	760	12,358	908	—
Japan	23,582	82,583	35,741	106,813	—	—
Indo-China	28,241	163,693	28,400	146,640	—	—
Algeria	80,429	363,805	74,066	484,240[2]	82,256	—
Tunis	27,900	113,680	37,400	224,400	30,300	—
United States	246,413	6,358,274	293,847	9,178,474	—	—
Mexico	46,181	98,841	40,743	81,926	—	—
Argentine	10	152	87	—	—	—
Bolivia	9,798	29,799	8,961	26,400	—	—

[1] *Spelter and concentrates.* [2] *Including lead ore.* [3] *Exports only.*

Occurrence of Zinc Ores

United Kingdom

Zinc ores occur and have been mined in many parts of the United Kingdom, but a large proportion of the output for several years past has been shipped to the Continent for smelting, although ores from foreign countries are imported and smelted (compare table on p. 613). The production of zinc ore in the United Kingdom during recent years is shown in the following table (*General*

Reports on Mines and Quarries, Part III, issued annually by the Home Office):

	1911.		1912.		1913.		1914.	
	Quantity.	Value.[1]	Quantity.	Value.[1]	Quantity.	Value.[1]	Quantity.	Value.[1]
	Tons.	£	*Tons.*	£	*Tons.*	£	*Tons.*	£
Dumfriesshire & Lanarkshire	109	507	952	3,808	1,010	3,850	1,057	4,228
Cumberland .	7,241	49,593	7,113		7,650		6,053	
Northumberland	3,787		4,482	57,378	4,161	46,344	3,930	31,558
Derbyshire .	560	1,568	597		475		450	
Shropshire .	134	546	386	2,145	444	2,267	424	2,381
Cornwall . .	300	450	—	—	—	—	—	—
Anglesey . .	455	910	—	—	—	—	31	30
Carnarvonshire .	545	2,345	97	364	782	2,036	10	40
Denbighshire .	884	6,633	512	3,645	498	3,003	151	796
Flintshire . .	610	2,931	652	2,773	537	2,438	846	4,224
Montgomeryshire . .	50	226	85	582	106	675	138	847
Cardiganshire .	1,116	4,924	778	3,614	678	2,977	708	3,955
Carmarthenshire	1	8	—	—	—	—	—	—
Isle of Man .	1,860	12,049	2,050	13,558	953	5,912	1,621	8,593
Total . .	17,652	82,690	17,704	87,867	17,294	69,502	15,419	56,652

[1] *Value at mines.*

The percentage of zinc in the ores raised in 1913 varied from 32 to 58 per cent.

Zinc ore has been raised from the Nenthead Mine, near Alston, in Cumberland, for a number of years, but since 1896 the product has all been exported to Belgium, the mine being worked prior to the war by the Vieille Montagne Co. Formerly the deposits were worked almost exclusively for lead, but now zinc ore constitutes about 90 per cent. of the total output; and in 1913 this mine produced more zinc ore than any other in the country. The main veins occur in hard limestones and sandstones, and dip steeply to the north. The mine is equipped with a concentrating plant capable of dealing with about 200 tons of ore in each 12 hours.

There is also a large output of zinc ore from the Nentsbury Mine, near Alston.

At the Thornthwaite Mine, a few miles from Keswick, galena and zinc blende occur in approximately equal amounts in lodes in the Skiddaw slates. The gangue consists chiefly of quartz. By separation and concentration both lead and zinc ores are recovered. The zinc

concentrates usually contain about 52 per cent. of the metal.

Zinc blende occurs associated with lead ore in veins in Carboniferous Limestone at the Carshield Mine, West Allendale, Northumberland, which, next to the Nenthead Mine in Cumberland, was the chief producer of zinc ore in the United Kingdom in 1913.

In the past, zinc ore has been mined in several localities in Durham, but no production has been recorded since 1910, when 74 tons were produced at the Willy Hole Mine at Harwood. Zinc ore occurs at Weardale associated with spathic iron and lead ore.

About 500 to 600 tons of zinc ore are annually produced in Derbyshire, the chief producing mines during the past few years being the Magpie, Sheldon, and the Mill Close, Darley. The ores occur in formations similar to those found in Cumberland.

At the present time, the Bog Mine of Minsterley is the largest producer of zinc blende in Shropshire, being followed by the Roman Gravels and Snailbeach Mines. The Roman Gravels Mine, which is situated in the Shelve district, has been producing small quantities of zinc ore for the past twenty years, whilst its lead veins have been worked at intervals probably ever since the Roman occupation. The principal workings run up the hill-side in the form of deep furrows. The lodes are composed chiefly of calcite and quartz, and, in addition to zinc blende, yield galena and iron pyrites.

Situated to the north of the Roman Gravels Mine is the Snailbeach, which is a very old working. The country rock is a hard quartzose, slightly micaceous schist of Llandeilo age. The lode, which varies in width up to 10 ft., carries zinc blende, galena poor in silver, and iron pyrites.

Zinc ore associated with lead was formerly obtained from veins in the Carboniferous Limestone in Somerset, but no production has been recorded for several years past.

In Cornwall, zinc ore occurs and has been worked at certain mines near Truro, and also in the neighbourhood

of Liskeard, where veins carrying zinc blende and galena traverse Devonian clay-slates. No output has been recorded since 1911.

Zinc blende is produced in small quantities from a number of localities in Wales, as shown in the table on page 616.

Anglesey produces small quantities of ore at irregular intervals from the Parry Mountain deposits.

In Carnarvonshire, the chief mines producing in 1913 were the Hafna and Llanrwst (Park), of Llanrwst, and the Trecastell of Conway. The New Pandora Mine of Trefriw has produced no zinc ore since 1910, when its output was 60 tons.

In Denbighshire and Flintshire, zinc ores occur in parallel lodes traversing Millstone Grits and Carboniferous Limestone. The deposits occur usually as crevice-filling veins, but in the limestone, pipes, caverns and flats occur, the last-named usually at the contact of the limestone and sandstone.

The only mine in Denbighshire which produced zinc ore in 1912 or 1913 was the Minera of Wrexham, where zinc blende occurs associated with argentiferous galena. This mine, which has produced zinc ore since 1864, was at one time the most productive lead mine in Great Britain.

The producing mines in Flintshire in 1913 were the Halkyn at Holywell, and the Rhosesmor and Waen in the Halkyn district.

In Cardiganshire, the deposits occur as lodes cutting strongly folded slates, shales, and sandstones of Cambrian and Silurian age. Zinc blende and galena are found in pipes and lenses connected by stringers in the vein-filling. The chief producing mines in recent years were the Ystumtuen, Rhiwfron; Cwrnystwyth and Kingside, Devils Bridge; and the Castell, Ponterwyd: whilst smaller quantities were produced from Brynyrafr, Talybont; Erwtowan, Rheidol Falls; and Penrhiw, Ponterwyd.

Zinc blende has been produced, together with galena, from at least one mine in the Isle of Man for many years past, the annual output varying between fairly wide limits.

The Great Laxey Mine was the only one being worked in 1913. The deposits occur chiefly at the contact between Lower Silurian slates and the granite upon which they rest. The annual production of the Great Laxey Mine is about 2,000 tons of ore, carrying 51·0 per cent. of zinc.

The Foxdale lode, which has been worked for a distance of 4 miles along its strike, has also yielded zinc blende and galena.

Australia

The most important zinc-lead deposits worked in the British Empire occur in Australia. These are the celebrated Broken Hill deposits of New South Wales, which have been worked on a large scale for many years past.

New South Wales.—The production of zinc ore in this State is exceeded in value only by the output from the United States and from Germany.

The deposits worked occur in the Broken Hill district, which is situated at the southern extremity of the Barrier Range. Broken Hill is a ridge standing about 200 ft. above the surrounding country. Its extreme length is about 2 miles, and it is bounded by plains on both sides.

The rocks consist of crystalline gneiss, mica schists, quartzites, and garnetiferous sandstones, all highly metamorphosed and probably of pre-Devonian age. These strike approximately north and south, and dip at steep angles. They are penetrated by bosses and dykes of granite, together with dykes of felsite, diorite, and basalt. The rocks have been bent into an anticlinal fold, the axis of which is coincident with the crown of the hill, the crystalline rocks dipping away, on either side, almost parallel to the slope of the hill.

The lode occupies the saddle-shaped cavity formed by the contortion of the strata, and its outcrop forms the highest part of the range for a distance of about one and a half miles. The saddle-shaped lode has legs dipping away to east and west. The eastern portion usually dips steeply, and has a tendency to thin out and to decrease in width. The western leg often takes the form of a bulging stump. As the anticlinal axis diverges in some

places from the horizontal, the lode occurs at varying depths from the surface. The walls are not always well defined, and in some places the ore occurs also in the adjoining country rock.

The outcrop of the lode, which has now been practically all removed, varied in width from 20 to 100 ft. and was composed of manganiferous limonite, lead carbonate, psilomelane, chloride, bromide and iodide of silver, together with an aluminous and siliceous gangue. Under the outcrop and between it and the unaltered sulphide minerals came three zones of oxidised ore. The first, or carbonate ore, consisted of material somewhat similar to the outcrop, and contained from 5 to 80 oz. of silver per ton and 20 to 60 per cent. of lead. The second, or "dry high-grade ore," zone consisted of kaolin, garnets, quartz, silver chloride, bromide and iodide, and native silver. It contained about 3 per cent. of lead and from 4 to 300 oz. of silver per ton. The third, or "low-grade dry ore," zone contained material very similar to the carbonate zone, but carried a smaller quantity of lead and 5 to 40 oz. of silver per ton.

Beneath these oxidised materials came the massive unaltered sulphide ores, the working of which was commenced about 1893. The primary sulphide ores consist of an intimate mixture of moderately fine-grained zinc blende and galena, with a gangue of rhodonite, quartz, calcite, garnets, and sometimes orthoclase felspar. The accessory minerals present may include iron and copper pyrites, mispickel, wulfenite, and fluorite, but, with the exception of pyrites, these are of rare occurrence. The galena and zinc blende are usually so intimately mixed that it is impossible to distinguish one mineral from the other in the mass.

In the early days of working these sulphides, the crude ore averaged about 25 per cent. each of lead and zinc with 25 oz. of silver per ton, but by 1904 the average grade had fallen to about 16 per cent. of lead and zinc and 11 oz. of silver per ton. The present-day average is probably rather below these latter figures.

By concentration and separation processes the ore yields two chief products: (1) zinc ore, containing about

45 per cent. of the metal, together with about 5 per cent. of lead, and (2) lead ore, carrying about 65 per cent. of lead, 6 per cent. of zinc, and varying quantities of silver.

As regards the destination of the lead and zinc concentrates produced, for several years past most of the zinc has been sold under long contracts to smelters in Belgium and Germany. The exceptions to this are the small quantity of about 20,000 tons which is exported to the United Kingdom and smelted at the Sulphide Corporation's works at Seaton Carew, and the ore treated by the Broken Hill Proprietary Company's plant at Port Pirie, South Australia. The disposal of the lead concentrates is on very different lines; at least half the ore is smelted locally, and the remainder was sold under short-date contracts, chiefly to German firms.

The Port Pirie smeltery takes the lead concentrate from the Broken Hill Proprietary, Zinc Corporation, Junction, Junction North, and Amalgamated Zinc Companies. The Sulphide Corporation smelts its ore at Cockle Creek, near Newcastle, N.S.W., together with the lead ore from Block 14 Mine. In the earlier working of the Broken Hill deposit for lead and silver, the zinc was neglected and enormous quantities of tailings and slimes accumulated from the concentrating plants. In addition to these some of the slags from the lead smelting also contained from 16 to 20 per cent. of zinc oxide. It was estimated by the New South Wales Department of Mines that, in 1903, there had accumulated zinc residues and tailings amounting to 5,687,400 tons, and these contained 18·6 per cent. of zinc. Numerous processes were tried in order to produce a marketable grade of ore from these residues, and it was finally decided that flotation processes were the most suitable. The importance of these residues, at the present time, is well illustrated by reference to the operations of only one company, the Amalgamated Zinc Company, which, in 1913, treated 498,289 tons of tailings which contained zinc, 17·1 per cent.; lead, 3·7 per cent.; and silver, 4·4 oz. per ton. From these residues were obtained 140,098 tons of zinc concentrates carrying zinc, 48·9 per cent.; lead, 5·9 per cent.; and silver, 8·5 oz. per ton. The lead

concentrates also produced amounted to 1,584 tons and contained lead, 57·1 per cent.; zinc, 15·0 per cent.; and silver, 35·2 oz. per ton. The lead and zinc concentrates together were valued at £392,182. In 1913, the total value of the products obtained by the companies engaged in treating zinc-bearing tailings was £776,228.

The annual output of crude ore from the Broken Hill district amounts to about 1,700,000 tons, and employment is found for about 8,800 men.

South Australia.—Quantities of metallic zinc have been exported from this State, but these have been produced from the smelting of ore from New South Wales. No workable deposits in the State have, so far, been recorded.

Queensland.—Zinc blende has been found associated with galena in certain mines in the Burketown Mineral Field in the north-eastern corner of the State. The minerals are accompanied by quartz and siderite as the chief gangue minerals, whilst arsenic and antimony are absent. The results of a number of analyses of typical samples of ore indicate that they contain on the average about 10 per cent. of zinc blende and about 13 per cent. of galena. It is stated that at least three mines could probably yield large quantities of milling zinc ore, whilst others might become low-grade producers. The development of the mines is likely to be retarded, however, as fuel is scarce. These deposits have been fully described by L. C. Ball in *Publication* No. 232, 1911, *Geological Survey of Queensland.*

Tasmania.—Important deposits of lead-zinc ore have been described as occurring in several localities in the island, but the output of zinc ore has so far been small. The more important of these are situated in the Read-Roseberry district on the west coast.

Mt. Read is situated about 17 miles by rail from Zeehan, and about 71 miles from the port of Burnie. The zinc-lead sulphide deposits have been shown, by mine workings, to occur over a length of 7 miles, extending from Mt. Black on the north to Mt. Read on the south. The Mt. Read group of mines has recently been described by L. Hills in *Geological Survey Bulletin*, No. 19, issued by the Department of Mines, Tasmania.

The zinc-lead deposits occur in a zone of the Read-Roseberry schists about 200 ft. thick.

The general composition of the ores from this locality is shown in the following table:

	Zinc. Zn.	Lead. Pb.	Iron. Fe.	Copper. Cu.	Gold. Au.	Silver. Ag.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Oz. per ton.*	*Oz. per ton.*
Mt. Read Mine, high-grade ore	43·2	13·8	10·17	0·15	0·13	12·7
Hercules Mine, B ore body	38·3	6·8	13·7	0·48	0·50	33·1
,, ,, No. 2 bore	32·5	16·8	6·5	0·30	0·07	40·7
,, ,, No. 7 bore, average sample	23·6	4·0	14·05	0·33	0·10	5·3
,, ,, No. 8 bore	28·8	7·2	10·42	0·38	0·13	5·9

The ore bodies are characterised by a very low proportion of gangue, the average quantity being about 10 per cent., and also by their pronounced banded structure. These bands, which dip at about 70° to the east, are of varying composition: thus, one may be predominantly zinc blende, whilst in a second the galena may be most noticeable, and pyrites may be the chief constituents in a third.

A large deposit of mixed sulphides of zinc and lead has been opened up at the Roseberry Mine on the western slope of Mt. Black. Numerous large and well-defined lodes have been located running across the strike of the stratified rocks. The country rock consists of micaceous schist with interstratified sheets of limestone, slate, sandstone, and quartzite, together with frequent intrusions of diorite.

Zinc blende occurs in the lead-silver mines of the Waiatah district to the west of Mt. Bischoff. In certain of the lodes it is the dominant metallic mineral.

New Zealand

Zinc blende occurs, associated with galena, at Bedstead Gully and the Perseverance Mine, Collingwood. It also is found at Tararu Creek, Thames, and on Great Barrier Island. There appears to be no evidence as to the economic possibilities of these deposits.

Canada

Although ores of zinc have been known for many years past to occur in Canada, their commercial utilisation has not attained much importance. Several factors have acted

as deterrents in this connexion, amongst which may be mentioned transport difficulties, and the hostile tariffs of the United States, but probably that which has proved most serious is the complex nature of the ores and consequent difficulty in smelting them successfully. At the present time, however, there seems to be no reason why this latter drawback should not be overcome, as ores similar in character are exported in enormous quantities from New South Wales to Europe.

Most of the zinc ore raised in the past has been exported to the United States, but had it not been for the enhanced value of the ore, due to its silver content, the working of the deposits would not have been a financial success.

In 1913, the United States import duty on zinc ore was reduced to 10 per cent. on the value of the zinc in ores containing over 25 per cent. of the metal and $\frac{3}{4}$*d.* per lb. on all lead contained therein. The quantities of zinc contained in the ores thus exported amounted to 2,900 metric tons in 1912, and 2,242 metric tons in 1913.

Bounties have recently been promised by the Dominion Government to encourage the production, in Canada, of metallic zinc from Canadian ore, and to protect producers against too great a fall in price between the end of the war and July 31, 1917, and by this means to ensure a certain supply of brass to the Shell Committee for the manufacture of quick-firing cartridge cases for shells. The bounties are on a sliding scale not exceeding 1*d.* per lb., when the standard price of zinc in London falls below £33 per ton of 2,000 lb. The zinc must not contain more than 2 per cent. of impurities. The total amount of the bounties to be so paid will not exceed $400,000 and will not be payable on zinc produced before the expiration of the war, or after July 31, 1917, or on zinc contracted for by the Shell Committee at 4*d.* or more per lb.

Owing to the large number of deposits which have been found to contain zinc in apparently workable quantities, it will only be possible here to describe briefly a few of the more important. For further details the Annual Summary Reports of the Geological Survey Branch of the Department of Mines should be consulted.

With a view to overcoming some of the above-mentioned difficulties, several attempts were made, some years ago, to smelt the ores in Canada. Thus, in 1904, a smeltery was erected at Frank, Alberta, but after a short time the work was abandoned owing to the process used proving unsuitable for Canadian ore. Electric smelting was tried at Nelson in 1908, at McGill University in 1910, and by the Department of Mines at Nelson in 1913. None of the electric smelting trials led to commercial success, chiefly, it is stated, owing to the trouble caused by condensation of the zinc in the furnace.

With a view to developing the industry in Canada, the Dominion Government, in 1910, voted $50,000 "for investigating processes used in the production of zinc, for making experiments and for any other purposes that may be deemed advisable for the promotion and manufacture in Canada of zinc and zinc products from Canadian ores." The question of zinc smelting in Canada has lately received further attention consequent on the great demand for zinc for munition purposes, and it is stated that success has been achieved by employing a combination of roasting, leaching and electrolytic processes. These will be described in Part II of this article.

British Columbia.—The most important zinc ore deposits now worked in Canada occur in this Province. Most of the zinc-producing mines have had the same history. Started as surface lead mines, they showed zinc blende as the development proceeded, and as the depth increased the proportion of the mineral became greater, until this and the silver constituted the most valuable portion of the ore. In many localities zinc blende occurs in small quantities with workable lead ore, and at the present time most of the zinc ore produced in Canada is obtained as a by-product from such deposits.

A full account, up to 1906, of the occurrence and economic possibilities of the zinc ores of British Columbia, has been given in the *Report of the Commission Appointed to Investigate the Zinc Resources of British Columbia and the Conditions affecting their Exploitation* (Ottawa, 1906). In the present article it will only be possible to

indicate briefly the main features of the more important districts.

The quantity and value of the zinc ore produced in British Columbia in 1911–14 are shown in the following table:

	Quantity.	Value.
	Metric tons.	£
1911	1,197	26,894
1912	2,434	65,862
1913	3,071	67,588
1914	3,575	72,109

The deposits in the Slocan district of West Kootenay yielded over 92 per cent. of the total production of British Columbia in 1914, the remainder being mined in the Ainsworth and Nelson districts.

The Slocan series of rocks, which are stated to belong to the upper or middle Palæozoic system, consist of dark carbonaceous argillites, limestones, quartzites, and greywackes, together with beds of tuff and ash. They are mostly thin-bedded and fissile and form the country rock of the larger part of the productive silver-lead mines in the Slocan district. The rocks, as exposed in the mines, consist largely of carbonaceous slates, intercalated with which are beds of quartzite and limestone. The slates are penetrated in many directions by porphyry dykes, which form massive intrusions and sheets. The silver, lead, and zinc deposits are almost entirely confined to the fissure veins in the slates formed subsequently to the porphyry dykes and granitic intrusions. These metalliferous deposits are here termed the Slocan veins.

Another type of deposit found in the Slocan series is one in which zinc blende occurs as replacements in limestone, in chimney-like ore shoots associated with the fissures. This latter type of deposit usually contains, primarily, argentiferous galena, the ore containing about 40 per cent. of lead, 10 per cent. of zinc, and up to 90 oz. of silver per ton. The zinc ore is usually associated with siderite and pyrites. Tetrahedrite and chalcopyrite sometimes occur with the galena and zinc blende, and in that case the latter often contains valuable quantities of silver.

Usually, there is no well-marked order of mineral

succession in the Slocan veins, but galena generally occurs at the outcrop and forms the hanging wall, whilst compact masses of zinc blende are found next, and siderite and quartz comprise the foot wall. As the depth increases the preponderance of galena over zinc blende decreases, and finally both become negligible in proportion to the quantity of quartz and siderite.

The most important producing mines in the Slocan district in 1913 and 1914 were the Standard, Silverton; Rambler-Cariboo, Mt. Guigan; Slocan Star, Sandon; Van Roi and Hewitt, Silverton; Hartney, New Denver. The Standard Mine is one of considerable importance as regards the zinc production of Canada, as its output in 1914 amounted to 2,272 tons of zinc, in addition to 4,545 tons of lead and 1,050,000 oz. of silver. Considerable development work has been done on the mine, which is equipped with modern concentrating plant. The greater proportion of the ore is now shipped to Trail for smelting. The Slocan Star resumed the production of zinc ore in 1914 after a stoppage of seven years. The lead-silver concentrate from this mine is sent for smelting to Trail, whilst the zinc-silver ore is shipped to Bartlesville, U.S.A., for treatment.

Ainsworth, one of the oldest mining districts in British Columbia, is situated about 28 miles by steamer from Nelson, on the eastern shore of Lake Kootenay. The geological formation is stated to belong to the Shuswap series and consists of mica schists, quartzites, gneiss, and crystalline limestones penetrated by many recent basic dykes. The ore deposits, which usually appear in the schists, conform to the plane of schistosity; but occasionally, when found in limestone, they are replacements of an irregular character. The quantity of silver accompanying the lead and zinc ores is usually small. A sample of ore taken across a width of 8 ft. in a stope will serve as being somewhat typical of the district. The sample contained 20·8 per cent. of zinc, 11·7 per cent. of lead, and 2·5 oz. of silver per ton. Associated with the ores occur varying amounts of pyrrhotite, chalcopyrite, and iron pyrites.

Small quantities of zinc ore have been shipped, at irregular intervals, for the past 10 years. The mines producing or shipping zinc ore in 1913 and 1914 were the Whitewater of West Kootenay and the Utica of Paddy Mountain. In 1905, when considerably less development work had been done on the deposits than is now the case, it was estimated that the Ainsworth district would be capable of producing from 15,000 to 30,000 tons of marketable zinc ore per annum. So far, however, nothing approaching this estimate has been attained.

In the Nelson district, zinc blende has been produced during the past few years from the H.B. Mine on Deer Creek, and the Zincton, both mines being situated near Salmo. The Monarch Mine of Field, East Kootenay, which had previously been an important producer, ceased its output in 1913. The ore from this mine consists of galena and zinc blende, together with a dolomitic and siliceous gangue. A mill having a capacity of 80 tons per day was in operation, and the concentrates obtained consisted of (1) galena carrying 67 per cent. of lead and under 9 per cent. of zinc; (2) zinc blende carrying 39 to 45 per cent. of zinc and about 2 per cent. of lead. The lead concentrates carried about 5 oz. of silver per ton, but the amount of this constituent present in the zinc concentrates was negligible. The lead ore was shipped to Trail, whilst the zinc ore was sent to the United States for smelting.

In the Portland Canal district of British Columbia zinc blende has been found in many places, but, except at the Ajax Mine, situated on the south fork of Glacier Creek, the percentage of ore in the vein is small.

The composition of samples of zinc blende from certain mines in British Columbia is shown in the following table:

Mine.	Zinc. Zn.	Lead. Pb.	Iron. Fe.	Sulphur. S.	Silver. Ag.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Oz. per ton.*
Slocan Star	56·70	0·14	6·23	29·84	2·80
Lucky Jim	60·80	1·75	3·84	30·65	2·00
Ruth	52·25	0·16	7·70	28·03	3·40
Whitewater	58·00	1·00	—	—	10
Van Roi	12·00	7·75	—	—	18
Wakefield	48·00	3·90	—	—	32

Ontario.—Although several promising deposits of zinc ore have been found in this Province, only small quantities of ore have been raised in the past, and these at irregular intervals. Thus, the value of the ore produced since 1906 has been as follows: 1906, $6,000; 1909, $8,950; 1910, $5,760. Since the latter date no production has been recorded.

Since 1906 all the ore produced has been obtained from the Olden Mine in Frontenac County. Here the zinc blende occurs, intimately associated with galena, in a crystalline limestone belonging to the Grenville series. The deposit is somewhat irregular in character, the ore occurring sometimes in veins and in other places in pockets of considerable size, some of the latter containing up to 200 tons of ore. The gangue consists chiefly of iron pyrites and greenstone. The galena is argentiferous, and may carry up to 20 oz. of silver per ton.

The Zenith Mine near Rossport, on the north shore of Lake Superior, is one of the oldest zinc ore producers in Canada, but no output has been recorded for several years past. Zinc blende, associated with iron and copper pyrites, here occurs in irregular masses in hornblende and diorite Huronian rocks. Owing to its inaccessible position, the deposit was not worked until 1898, although its existence had been known for twenty years previously. After considerable development work had been done, and about 2,000 tons of ore, averaging 45 per cent. of zinc, had been shipped to Belgium, the mine was abandoned in 1901, owing to the low price of zinc ore. The mine is now receiving attention with a view to its being re-opened and worked. Several other outcrops of zinc ore occur within a few miles of this property.

In Lake township, Hastings County, the Katharine Mine was opened up in 1900 and zinc blende was found associated with argentiferous galena in a vein of calcite occurring in diorite, the vein varying in width from 1 to 4 ft. Two shafts were sunk and diamond drilling carried out to a depth of 292 ft.

A considerable proportion of zinc blende occurs with galena at the Victoria and Cascade Mines of Garden River, near Sault Ste. Marie. The mineral has also been

recorded to occur in quantity at Mazokama River and at Wolf River to the north-west of Black Bay, Lake Superior.

About 4 miles from Wiarton in the township of Albemarle East, Bruce Peninsula, zinc blende was found filling pore spaces and cavities in dolomite. Prospecting was carried out by means of an open cut and several car-loads of ore were shipped to the smelters.

Quebec.—So far as can be ascertained the only mine which has produced zinc ore is situated on Calumet Island, Pontiac County. The zinc blende deposits occur, associated with galena, in dioritic rocks which are intrusive through grey gneiss and limestone. The deposits are stated to be of considerable extent, but pockety in character.

Nova Scotia.—A deposit containing zinc blende associated with galena, pyrrhotite and mispickel, occurs in a bed of sericite schist at Faribault Brook, a branch of the Cheticamp River, Inverness County, Cape Breton.

Newfoundland

Zinc ore has been found in several localities in the island. Several years ago, a promising deposit yielding lead, zinc, silver, copper, and a little gold was located at Buchan's River, Red Indian Lake. A shaft 300 ft. deep was sunk and a vein 9 ft. wide was struck. The ore usually occurs in lenses.

India

During the past fifty years zinc ores have received but little attention in this country, and no production was recorded until 1913. Recently, however, considerable work has been done on at least one deposit, and there is a prospect of India becoming an important producer of zinc ore. In 1914, the production was 8,553 tons, of value £10,762.

Important silver-lead-zinc deposits occur at Bawdwin, in Tawnpeng State, one of the Northern Shan States in Upper Burma. The mines are connected with the Mandalay-Lashio branch of the Burma railways by a narrow-gauge line 51 miles long, the lines meeting at Manpwe, which is about 544 miles from Rangoon. They were worked for many centuries by the Chinese for silver, and

have long been known to contain zinc ore; until recently, however, no serious attempt appears to have been made to market the ore for its zinc values. In 1907, the present undertaking was started by the Burma Mines, Ltd., with the idea of recovering the lead from the old slag heaps left by the Chinese, estimated at 125,000 to 160,000 tons, and later to work the open ground below a vast open cut.

Smelting operations on these slags were first carried out at Mandalay, but later the works were transferred to Namtu, about 13 miles below the mines on the narrow-gauge railway.

The deposits, which comprise an area of 2,496 acres, have now been taken over by the Burma Corporation, Ltd., and one is being worked. This consists of nearly vertical ore shoots in felspathic grits, locally classified as the Bawdwin series. The hanging wall is felspathic grit, whilst the foot wall is more generally a rhyolite. The ore channel is from 350 to 500 ft. wide, and has been traced for a length of 8,000 ft. At present, the development work is concentrated on the northern 4,000 ft., where the ore outcrops at the surface. The principal ore body, which has been opened up at the Chinaman tunnel level for a distance of 1,300 ft., has an average width of 49 ft. The ore is somewhat complex in character, and has been classified into four grades, which are stated to have the following average composition:

	Silver. Ag.	Lead. Pb.	Zinc. Zn.	Copper. Cu.
	Oz. per ton.	*Per cent.*	*Per cent.*	*Per cent.*
Zinc-silver-lead ore	24	26	30	—
Lead-silver-zinc ,, ...	17	24	14	—
Silver-lead-zinc ,, ...	40	30	26	—
Copper-silver ,, ...	8	—	—	15

The greater part of the development work now in progress is being carried out on the Chinaman ore body. The company is producing about 750 tons of metallic lead per month, but, so far, does not appear to have smelted any zinc, although prior to the war it was selling about 2,000 tons of zinc-lead ore per month to continental smelters. This latter ore is stated to be now accumulating at the mine at the rate of 1,500 to 2,500 tons per month.

It is proposed to increase the plant at the mine very considerably, so as to cope with an annual output of 300,000 tons of ore. An account of the recent development of the workings will be found in *Engineering and Mining Journal* (1915, **99**, 177).

Ore similar to that found at the Bawdwin Mines is reported to occur at the Mohochang Mines, situated about 20 miles to the north. Here also occur extensive ancient workings and slag heaps.

It has been stated by V. Ball (*Geology of India*, 1881, III, 312) that zinc ore occurs in workable quantities in Udepur State at Jawar. It is probably the carbonate, smithsonite, and occurs in quartz rock in veins 3 or 4 in. wide. The ore appears to have been smelted by native methods many years ago, but the mines were closed down in 1812, and have not since been re-opened.

In Sirmur State, zinc blende associated with galena, iron pyrites, and quartz occurs at the Sirmur-Jaunsar Mine. Zinc blende has also been found associated with antimony ore near the Shigri glacier in Lahaul.

Egypt

Small quantities of zinc carbonate are produced from the ancient workings at Gebel Rosâs, near the Red Sea, where it occurs in limestone associated with lead sulphide and carbonate. Analyses of the ores show up to 37 per cent. of zinc and 58 per cent. of lead. The workings were re-opened in 1913 by the Compagnie française des Mines de Laurium. In 1913 these mines produced 1,543 tons of lead ore, and 1,967 tons of zinc ore.

Zinc carbonate is also recorded in a crystalline limestone close to Safâga Bay and in the gypsum area of Bir Ranga.

Nigeria

In the *Report on the Results of the Mineral Survey in Southern Nigeria* for 1905–6 ([Cd. 4994], 1910, pp. 21–25) it was pointed out that lead and zinc ores occur in the Abakaliki district, and this received further confirmation in the *Report* for 1908–9 ([Cd. 5901] 1911, pp. 10–12). The most noticeable of the deposits is a lode occurring at Alusi Hill,

Ifotta, near Enyiba. These lodes in the hill have been extensively worked by natives, the dominant minerals present being galena, zinc blende, and siderite, occurring in a country rock of mudstone and slate. Prospecting operations carried out by the Surveyors showed that in the Amana section of the deposit at least three distinct lodes occurred, viz. one consisting of lead, zinc and iron ore, and two of zinc and iron ores.

Six bulk samples from the Amana section of the Ifotta lode were examined at the Imperial Institute and gave the following results:

	Lead. Pb.	Zinc. Zn.	Copper. Cu.	Gold. Au.	Silver. Ag.
	Per cent.	*Per cent.*	*Per cent.*	*Oz. per ton.*	*Per ton.*
1	65·49	0·73	trace	nil	2 oz. 10 dwt. 15 gr.
2	55·21	6·99	0·56	,,	2 ,, 6 ,, 9 ,,
3	38·87	3·49	trace	,,	1 ,, 8 ,, 2 ,,
4	33·31	1·11	0·088	,,	1 ,, 19 ,, 20 ,,
5	24·65	1·33	0·04	,,	1 ,, 18 ,, 13 ,,
6	0·82	30·40	0·12	,,	0 ,, 7 ,, 12 ,,

Rhodesia

Although zinc ore has been observed in several localities in this country, the only deposit of commercial importance so far located occurs in the Broken Hill district, associated with galena. According to recent reports the deposit, which outcrops in the form of kopjes from an open vlei, is being actively developed, and a smeltery for lead and zinc is in course of erection. The amount of ore exposed by work on one of the kopjes to a depth of 18 ft. is estimated to be 140,000 tons, containing on the average about 26 per cent. of lead and 22 per cent. of zinc. The latter occurs chiefly as carbonate, but sulphides are also present. The ore content of a second kopje is estimated to be about 300,000 tons, carrying about 32 per cent. of zinc.

Union of South Africa

Although zinc ores have been reported to occur with lead ores in several localities in the Union, in most cases little work has been done towards proving the value of the occurrences. Most of the deposits so far developed are in the Transvaal.

The most important deposits hitherto described occur in the Malmani division near Ottoshoop, in the Western Transvaal, the chief mines being the Buffelshoek and Witkop Mines. Prospecting has also been carried out in the Marico, Pilgrim's Rest, and Waterberg districts.

In 1914, a concentrating plant was installed at the Blane-Witkop Mine for the treatment of zinc ore, and was worked for a short time; but it was found impossible to dispose of the concentrates at a remunerative rate owing to the export of ore to Germany being prohibited, and the smelters in the United Kingdom and United States having more ore than they could deal with. About 200 tons of concentrates, carrying about 50 per cent. of zinc, were produced during the short time the plant was running.

In the former German colony of South-West Africa, zinc blende occurs with copper ore and galena at Tsumeb in the Otavi district (see this BULLETIN, 1915, **13**, 246).

NOTES

Ceylon Plumbago.—In the early part of the year 1914 general depression in trade was responsible for a reduction in the exports of Ceylon plumbago, which were also suffering to some extent from the competition of plumbago from other sources.

Soon after the outbreak of war the position of the plumbago mining industry became serious owing to the prohibition of exports to foreign countries, and at the end of the year 1914 the total exports of plumbago proved to have been only 286,021 cwts., as against 575,944 cwts. in 1913. Early in 1915 the situation was partially relieved by the modification of the restriction on exports to the United States of America, which is the chief importing country. Nevertheless, the loss of the German and Belgian markets was a serious matter to Ceylon producers, and with the view of replacing this loss action was taken by the Imperial Institute to induce users of plumbago in the United Kingdom to buy the whole of their supplies from Ceylon, instead of partly from Ceylon and partly from foreign countries as hitherto.

The quantity of the mineral taken from Ceylon by Germany and Belgium in 1913 was 162,926 cwts., and by the United Kingdom 106,954 cwts. In the same year the United Kingdom imported 281,380 cwts. of plumbago from foreign countries, and it was therefore clear that a quantity

of plumbago equivalent to that formerly shipped from Ceylon to enemy countries could easily be absorbed by the United Kingdom if British buyers would specify the Ceylon instead of the foreign product.

As a result of the efforts of the Imperial Institute, the interest of many British users of plumbago was aroused, and several expressed their intention of using Ceylon plumbago instead of the foreign mineral.

That the situation in Ceylon has improved in the course of the year 1915 is shown by the following comparative table of the quantities exported during the first ten months of the years 1914 and 1915.

It will be seen that the exports to the United Kingdom have more than doubled, Russia has become an important purchaser of Ceylon plumbago, and a satisfactory increase in exports to the United States has taken place.

Exports of Plumbago from Ceylon during the first ten months of 1914 *and* 1915

To	1914. January to October. Cwts.	1915. January to October. Cwts.
United Kingdom	36,612	86,952
Russia	79	35,951
United States	136,562	186,599
Victoria	5,361	3,915
New South Wales	100	362
India	978	746
Japan	1,276	312
Other Countries	82,466 [1]	—
Total	263,434	314,837

[1] *Including Germany, Belgium, France, Austria, and other countries to which no shipments have been made during* 1915.

Forest Administration in British India, 1909–14.—A quinquennial review of forest administration in British India has been issued recently which contains a good deal of interesting information. Three classes of forest land are controlled by the Forest Department: (1) reserved forests, with clearly defined boundaries and carefully recorded rights; (2) protected forests, in which the demarcation of boundaries and record of rights are less perfect; and (3) unclassed State forests, over which the control of the Department is generally confined to revenue collection until suitable areas are converted into reserved or protected forests or are taken up for cultivation. At the close of the quinquennial period under review, the total forest area of British India (including the Shan States) was 245,612 square miles, and consisted of 96,297 square miles of reserved forests, 8,390 of protected forests, and 140,925 square miles of unclassed State forests.

The measures which have been taken to protect the forests from fire have, in most cases, been very beneficial.

In some cases, however, the protection afforded has been detrimental to the natural regeneration of the forests, as the encouragement given to inferior species and weeds has interfered with the survival of seedlings of the principal species. This effect has been observed in the moister types of teak forests in Burma, and the protection given in such cases is being withdrawn. Similar results have been noticed in the "sal" (*Shorea robusta*, Gaertn.) forests of Bengal and Assam, where the continued protection has permitted the undergrowth to become so dense as to affect the aeration of the soil, and thus prevent the "sal" seedlings from establishing themselves.

The work done in connexion with diseases and pests has included investigations of (1) the mysterious spike disease of the sandal tree, (2) a fungoid pest (*Trametes pini*) which attacks the blue pine (*Pinus excelsa*, Wall.) of the Himalayas, (3) a deodar needle fungus (*Peridermium cedri*) which causes great damage to the deodar plantations in Kulu, and (4) a virulent fungus which has been found on the roots of *Shorea robusta*, Gaertn., and has caused the death of large numbers of trees. Energetic measures have been taken for the eradication of Lantana, a shrub which has covered extensive tracts in Southern India, to the exclusion of nearly all other forms of vegetation. Large areas have been cleared in Coorg, and special legislation has been enacted with reference to this weed.

Several industries dependent on the supply of forest products have been started recently or are under consideration. One of the most important of these is the utilisation of bamboo, savannah grasses, and fir wood for the manufacture of paper pulp. The manufacture of bamboo pulp has been carried out successfully on a commercial scale, and concessions for the extraction of bamboos have been granted to two firms in Burma and Bengal. In the Punjab, a concession has been granted for the extraction of spruce and silver fir from the Kulu forests for wood-pulp manufacture. Special attention is being given to the production of tanning extracts from mangrove bark and other materials. Efforts have been made to stimulate the utilisation of Indian woods for the manufacture of matches, and several factories have been established on modern lines. A tea-box manufacturing industry has been established in Assam, which has been fostered by the remission of royalties on tea-box wood, by devising measures for the protection of the timbers, and by forming experimental plantations of "simal" (*Bombax malabaricum*, DC.). Railway sleepers have been largely obtained from "sal" (*Shorea robusta*, Gaertn.) and deodar (*Cedrus Deodara*, Loud.), but as the supply of these woods is limited experiments have been conducted on the antiseptic treatment of less durable timbers, and arrangements

have been made to supply the Railway Board with a large number of treated "chir" (*Pinus longifolia*, Roxb.) sleepers from the forests of the United Provinces, and of "gurjun" (*Dipterocarpus turbinatus*, Gaertn.) sleepers from the Andamans. Considerable progress has been made in the manufacture of rosin and turpentine from the crude oleo-resin of the pine trees in the Himalayan forests, and new distilleries have been erected in the Punjab and United Provinces.

Forestry Work in Cyprus.—In early times the island of Cyprus was covered with rich forests, but indiscriminate felling, the action of fire, and the grazing of goats completely destroyed them in many parts and ruined them in others, with the result that large areas of the island, especially on the hills, became arid wastes. Since the British occupation in 1878, however, the conditions have improved. All the forests have been demarcated, indiscriminate felling and the clearing of land for temporary cultivation have been stopped, and a system of fire protection has been inaugurated, whilst the goat-grazing danger was dealt with by a law passed in 1913. Even at the present time, however, the damage done by goats is considerable; it was estimated that the damage caused by the 50,730 goats grazing in the forests in 1914–15 amounted to £25,000 (*Report on Cyprus for* 1914–15, *Colonial Reports*, *Annual Series*, No. 865 [Cd. 76622–56], 1915, p. 29).

Owing to the excessively dry summers natural regeneration is very feeble, and with a view chiefly to the production of fuel, plantations have been started in various parts of the island, the first being planted in 1881. A report on the plantation work carried out in Cyprus up to 1914 has been made recently by Mr. A. K. Bovill, Chief Forestry Officer (*Government Printing Office*, *Nicosia*, 1915), and shows that considerable progress has been made. Few plants have been found to do well on the bare, dry hills; the most successful has been a species of wattle (*Acacia cyanophylla*, Lindl.), which thrives where more valuable wattles die out, and when cut down grows up readily again from the stool. At Athalassa 1,800 acres have been planted with this wattle, and the trees now being established are used as nurse trees, large quantities of seeds of *Pinus halepensis*, Mill., *P. Pinea*, Linn., and *Quercus* spp. being sown under them every year. The plantation is laid out for a six years' rotation cutting, and it is thought that in time it will produce a cheap supply of firewood sufficient for the needs of Nicosia.

Successful plantations also exist at Kythraea (pines, cypresses, eucalypts, casuarinas, and wattles), and for 30 miles along the railway between Nicosia and Famagusta (wattles, eucalypts, casuarinas, and cypresses). In the

neighbourhood of the latter town the most important plantation is that at Salamis, which will supply Famagusta with fuel and brushwood. The most successful tree is the wattle already mentioned, and since this grew up and gave protection, pines which had previously been stunted have made an annual growth of from 1 ft. to 3 ft. 6 in. A very large number of species have been tried at this plantation, but most have failed, although *Cupressus guadalupensis*, S. Wats., *Dodonaea viscosa*, Jacq., and *Fraxinus velutina*, Torr., have proved satisfactory.

At Achna and Xylotymbou, situated midway between Famagusta and Larnaca, about 240 acres have been ploughed and sown with *Acacia cyanophylla*, Lindl., *Pinus Pinea*, Linn., *P. halepensis*, Mill., *Ailanthus glandulosa*, Desf., *Cupressus sempervirens*, Linn., and *Dodonaea viscosa*, Jacq. The results have been exceptionally good, one wattle sown in January 1912 measuring 13 ft. in height in May 1914, whilst many of the pines had reached a height of 27 in. during the same period.

Among other successful plantations reference may be made to those at St. Lazarus Marsh, Larnaca—which has been converted from one of the most unhealthy spots in the island into a veritable forest—at Larnaca Salt Lake, and on what was previously drifting sand between the Limassol-Larnaca road and the sea.

Rainfall data over a number of years are given for most of the districts where plantations have been established, which indicate that the climate is becoming moister, and this apparently is directly due to the tree planting which has been done in recent years. For example, at Athalassa the mean annual rainfall during the period 1904-5 to 1908-9 was 14·14 in., and that during the four subsequent years was 15·13 in. The corresponding figures for Salamis were 15·03 in. and 19·24 in. At Pergamos, a village close to the Achna and Xylotymbou plantations, the mean annual rainfall for the five years ending 1907-8 was 16·31 in., and for the five subsequent years 18·39 in., whilst at Khalevga the figures for these years were 40·50 in. and 61·69 in.

Dates of Egypt and the Sudan.—In connexion with the work of the United States Department of Agriculture on the cultivation of the date palm (compare this BULLETIN, 1914, **12**, 507), an expert of the Bureau of Plant Industry was sent to Egypt and the Sudan in 1913 to study the date-growing industry of the Nile Valley and to determine the characteristics of the principal varieties grown. An account of the climatic conditions of the different date regions and a description of twenty-two varieties of dates have been published as *Bulletin* No. 271, 1915, *U.S. Dept. Agric.*

It is estimated that there are about nine million date palms in Egypt and the Sudan, of which about three-fourths are of the "balady" or seedling type. Most of the latter yield fruit of inferior quality, which is consumed by the poorer classes of people in the immediate neighbourhood of the trees. The cultivation of dates is carried on in almost all parts of the Nile Valley from the Mediterranean coast to Khartoum. In order to show the influence of climatic conditions on date production, this region is divided into three zones: (1) the Nile Delta below Cairo, (2) the Nile Valley from Cairo to Assuan, and (3) the date-growing areas of the Nile Valley between Assuan and Khartoum. The records of the meteorological stations in these zones are tabulated and their relation to the requirements of the date palms is discussed. In the first zone, comparatively few dates are produced for export, but the greater part are consumed in the fresh state. In the second zone, dates of superior quality are produced in the moderately hot and dry localities, but the prices obtained for the crop could be greatly increased by the adoption of improved methods of packing. In the third zone, the dates produced are almost exclusively of the hard, dry kinds; the reasons for the preponderance of these varieties are the climatic conditions and the ease with which such dates can be cured, stored, and carried in camel caravans by the Arabs as an article of food.

The *Bulletin* contains much valuable information and is well illustrated.

The Copra Industry of the Pacific Islands and the War.—A report of an interview with Col. the Hon. J. Burns, Member of the Legislative Council of New South Wales and head of a well-known firm of merchants and shippers, appears in the *Shipping Gazette Weekly Summary* for December 3, 1915, in which reference is made to the effect of the war on the copra industry of the Pacific Islands. Copra is the staple commercial product of the various groups of islands, such as Fiji, Tonga, Samoa, and others, and prior to the outbreak of war the principal port for island copra was Sydney. Since the war started the greatest difficulty has been experienced in obtaining tonnage for the transport of copra from Sydney to Europe, and in consequence there has been great delay and freight charges have risen to an extraordinary extent. This position of affairs has enabled American shippers to capture a large proportion of the copra trade and divert it from Sydney to San Francisco. For some time past American sailing vessels have been engaged in transporting lumber from North Pacific ports to Australia. These vessels now come direct to Sydney, where they discharge part of their cargoes, and then proceed to the islands with the balance. At the islands they

load up with copra and proceed with it direct to San Francisco, thus obviating the expense of transhipping. The freight charges from the islands to San Francisco by these vessels is said to be less than one-half the cost of shipping from Sydney to Europe, and this gives the mill-owners at San Francisco a great advantage. As a result of the increased supplies of copra, the copra-crushing plant at San Francisco has recently been doubled in order to deal with it, and it is stated that an export trade in coconut oil has been started with Vladivostok, where a market for this oil has recently come into existence. A considerable amount of island copra is also being sent to Japan, the trade having originated since the war, on the occupation by Japan of several Pacific Islands which were formerly German possessions.

The increase in the imports of copra into the United States, chiefly by way of the Pacific port of San Francisco, is shown by the following statistics which are taken from the *Monthly Summary of the Foreign Commerce of the United States*, for June 1915:

Total Imports for the Twelve Months ending with June

1913.	1914.	1915.
305,962 *cwts.*	405,688 *cwts.*	808,453 *cwts.*

The Improvement of Wheat in the United Kingdom.—The wheat generally grown in this country cannot compete satisfactorily with imported wheats for bread-making purposes, and as it is highly desirable that the quantity of wheat grown in the United Kingdom should be increased, it follows that if the farmers are to obtain reasonable profits, both quality and yield must be improved. In order to enquire into the conditions affecting quality in wheat, and if possible to effect such improvements, the Home Grown Wheat Committee was established in 1901 under the auspices of the Incorporated National Association of British and Irish Millers (cf. this BULLETIN, 1911, **9**, 292). The Chairman of the Committee is Mr. A. E. Humphries, who is a well-known wheat expert, and amongst the members are Mr. A. D. Hall, M.A., F.R.S., of the Development Commission, and Prof. R. H. Biffen, M.A., F.R.S., Professor of Agricultural Botany, Cambridge University.

The *Report* of the Committee for the seasons 1913–14 and 1914–15, which has been issued recently, shows that considerable progress has been made. A large number of English, Colonial, and foreign wheats have been tested, and varieties have been found which, when grown in the United Kingdom, possess the inherent and hereditary characteristic either (*a*) of yielding maximum crops of grain and straw, or (*b*) of being either immune or highly resistant to certain forms of disease, or (*c*) of yielding grain of first-class bread-making quality. No existing variety

has so far been found which unites all these characters when grown in the United Kingdom, and the principal effort of the Committee is now directed "to obtaining from parents possessing at least one of these good points, by means of hybridising and Mendelian selection, a number of varieties, each one in the highest degree suitable for one or more of the differing 'environments' found in the United Kingdom."

The most promising varieties as parents are the Canadian Red Fife and White Fife. A wheat known as Red Fife imported from the Pacific districts of the United States was found to be exceedingly weak, and it seems that it is not the same variety as Canadian Red Fife. Crosses have been made with certain strains of Canadian Fife wheats and several of the best-known English varieties, and from the F_2 generation large numbers of types have been isolated and fixed. Certain of the crosses have been grown in sufficient quantity for extended trials in the bakehouse, and if these are satisfactory the new forms will shortly be distributed for trial throughout the country in order to obtain further information as to their suitability for general culture. Breeding experiments are also being conducted with a view to obtaining short-season varieties, some wheats from Szechuan, China, in addition to the Fifes, promising to be of unusual value for crossing purposes in this direction.

Agriculture in Japan.—An interesting account of Japanese agriculture, furnished with a number of excellent illustrations, has been issued by the Agricultural Bureau, Department of Agriculture and Commerce, Tokyo, under the title "Outlines of Agriculture in Japan."

Japan is essentially an agricultural country, about 60 per cent. of all the households being engaged, either wholly or in part, in farming. The land under cultivation amounts to about 15 per cent. of the total area, and half of this is devoted to rice. After the rice crop has been harvested and the water drained off, another crop such as barley, wheat, rape, or a green manure can be raised the same year. This is the case with about 40 per cent. of the total area of the rice fields, but not with those which are badly drained or situated where the climate is unfavourable.

On high and dry lands which are not used for rice cultivation, a rotation system is followed and two crops a year are raised. As summer crops, soy beans, millet, tobacco, hemp, sugar-cane, indigo, sweet potatoes and other vegetables are cultivated, and as winter crops, barley, wheat, rape, or vegetables. Mulberry trees, tea, fruit trees, and the paper mulberry are also planted in the uplands. In growing vegetables in the vicinity of a city by intensive cultivation three crops a year are produced.

Agriculture in Japan is conducted on a small scale and is intensive. Artificial manures have been increasingly used in recent years, and considerable quantities of soy bean cake, obtained from China and the Kwangtung Peninsula, are applied to the land.

The annual value of the agricultural produce of Japan is roughly estimated at £172,000,000. Of this value, cereals represent 72·4 per cent.; fruit, vegetables, and flowers, 11·4 per cent.; silk cocoons, 9·6 per cent.; industrial crops, including tea, rape, tobacco, sugar, and rushes, 3·8 per cent.; livestock and poultry, 2·5 per cent.; and miscellaneous produce, 0·3 per cent.

The principal agricultural crops, in order of the acreage under each in 1912, are rice, naked barley, barley, wheat, soy bean, mulberry, sweet potato, Indian millet, buckwheat, rape, a small red bean, potato, barnyard millet, tea, sorghum, tobacco, hemp, indigo, and cotton.

Japan is the chief silk-exporting country of the world. The value of the exports of raw silk increases steadily, and in 1913 reached £20,000,000, of which 70 per cent. represented shipments to America. The principal centres of the silk industry are the Nagano, Gumma, Saitama, Aichi, and Fukushima Prefectures. Of late, marked progress has been made in methods of sericiculture, and cocoons are harvested two or three times a year. In former times the silk was reeled by hand by the wives and daughters of the farmers, but to-day 70 per cent. of the total output is reeled by mechanical means.

Stock farming makes slow progress. The Government, however, is encouraging its development, and the breeds have been greatly improved by introduction of new blood from abroad.

There is a well-organised Department of Agriculture and Commerce, which deals with forestry, fisheries, and mining matters, in addition to agriculture. The Bureau of Agricultural Affairs, under the Department, has control of a number of special institutes and stations where scientific work is carried on. Among these mention may be made of the Imperial Agricultural Experiment Station, the work of which is classified under nine divisions: agriculture, agricultural chemistry, entomology, pathology, tobacco cultivation, horticulture, stockbreeding, soil investigation, and tea manufacturing, each of which is under the direction of a specialist. The station is situated near Tokyo, and there are three branch stations, special horticultural farms, and 39 local experiment stations.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.*

AGRICULTURE

Soils and Manures

Reclamation of Bog Land in Ireland.—The question of manuring in relation to the reclamation of bog land is discussed in *Journ. Dept. Agric. Ireland* (1915, **15**, 724). Pot and plot experiments with nitrogen, phosphate, potash and lime manures showed that in most cases lime is the controlling factor, in the absence of which the other materials are of little value in the reclamation of such land. In this respect the Irish bogs tested differ from some of the American bogs, where potash was found to be the controlling factor (cf. this Bulletin, 1913, **11**, 340).

Composition of Pacific Seaweeds.—An account is given in the *Journ. Agric. Research* (1915, **4**, 21) of experiments carried out at the California Experiment Station on the availability of the nitrogen in three important seaweeds of the Pacific coast, viz.: *Macrocystis pyrifera*, Agardh, *Nereocystis luetkeana*, P. et R., and *Pelagophycus porra*, Leman. It was found that the nitrogen of *Nereocystis* was relatively very available, while that of *Pelagophycus* was less readily converted into an assimilable form. *Macrocystis pyrifera*, the most important commercially, is very slowly changed in the soil; the availability of its nitrogen is greatest when the seaweed is applied in a fresh or partially dried condition.

The results of an investigation of the organic constituents of seaweeds, chiefly of the three varieties mentioned above, are given in the same *Journal* (1915, **4**, 39). The seaweeds were found to possess a high sulphur content, dried plants of *Iridaea* spp. containing as much as 8·16 per cent. of combined sulphur. Fronds of *Macrocystis*, *Pelagophycus*, and *Nereocystis* contained from 1·03 to 1·27 per cent. of combined sulphur, and the stems from 0·45 to 0·82 per cent. A large proportion of the nitrogen was found to be present in a non-protein form. Comparative laboratory experiments on the destructive distillation of seaweed and a consideration of its possible feeding value indicated only slight possibilities of commercial value in these directions.

The Micro-Organisms of Soils.—Reference has been made already in this Bulletin to the fact that certain minute

forms of animal life, known as protozoa, have a harmful effect on soil bacteria, and, as a consequence, on the fertility of the soil; methods of treating soils so as to overcome such effects have also been mentioned (1911, **9**, 289; 1913, **11**, 151, 677; 1914, **12**, 475). Results of further investigations on soil protozoa have been published recently. Cunningham (*Journ. Agric. Sci.*, 1915, **7**, 49) has confirmed earlier results and has shown that, both in solutions and in soils, the protozoa have a decidedly limiting effect on the number of bacteria. Experiments showed that most of the protozoa in the soil thrive best at a temperature of about 22° C., but that certain of them are adapted to a temperature of about 30° C. It is suggested that the latter forms may be of importance in sewage and in water-logged soils during hot summer weather in temperate regions and also in the rice-fields of tropical countries.

An exhaustive investigation of the conditions affecting the development of a number of different genera of protozoa is described in *Journ. Agric. Research* (1915, **4**, 511). In culture solutions inoculated with soils, the development of the various protozoa depended on the nature of the medium, the quantity of soil used for inoculation, and the temperature. Drying the soil before inoculation generally resulted in a slower development of these organisms than was the case when moist soil was used.

Foodstuffs and Fodders

Wheat.—The cost of production of seed wheat on an area of 345 acres in Victoria has been determined by the Department of Agriculture, and the results of the experiment are recorded in the *Journ. Dept. Agric., Victoria* (1915, **13**, 406). The total cost, including charges for cultivation, seed and manure, and allowing average market values for the fodder for the farm animals, instead of the abnormally high prices ruling at the time, was £403 3*s.* 4*d.*, or £1 3*s.* 4½*d.* per acre.

Increased attention has been given to wheat growing in Uganda, particularly in Toro, where 500 acres are under cultivation (*Ann. Rep. Dept. Agric., Uganda*, 1914-15).

Maize.—In the *Ann. Rep. Dept. Agric., Nyasaland*, 1914–15, reference is made to the experimental cultivation of maize on plots at Naisi. The yields of maize obtained on different plots were (1) directly following previous crop of maize without manuring, 625 lb. per acre; (2) following ground nuts, 861 lb. per acre; (3) following velvet beans, 879 lb. per acre.

Tea.—An account of the progress of tea cultivation in the Nyasaland Protectorate is given in the *Ann. Rep. Dept. Agric., Nyasaland*, 1914–15. The export of tea from

Nyasaland for the year ended March 31, 1915, was 166,248 lb., value £4,156, as compared with 116,074 lb., value £2,902, in the previous year. The area under cultivation increased from 2,870 acres to 3,303 acres. Tea is steadily gaining popularity as a crop in Nyasaland, owing to its permanent nature, its freedom from disease, and the satisfactory prices realised. Only a small area of the tea planted has yet reached full bearing, and it is therefore probable that the exports will increase steadily for some years. It has been demonstrated that tea can be grown successfully in the Cholo section of the Blantyre district, where, although there is an annual rainfall of 65 to 70 in., the crop is subjected to considerable periods of drought. Planters and companies are therefore encouraged to start tea plantations on an experimental scale in parts of the country which were formerly considered unsuitable for the crop. There is a difference of opinion as to the relative value of green manuring and clean weeding for tea, but on many soils considerable improvement has been effected by forking in leguminous crops; and even where the land is clean-weeded forking around the plants has proved beneficial.

Cocoa.—An important discovery is announced in the *Rep. Agric. Dept., Gold Coast*, 1914, that the kapok or silk cotton tree, *Eriodendron anfractuosum*, DC., is a host of the cocoa-pest "Sankonuabe," *Sahlbergella singularis*, Hagl., through whose activities, facilitated by lack of attention to details of cultivation, many thousands of acres under cocoa in the Gold Coast have been rendered worthless. It had been observed that cocoa trees bordering upon the forest are the first to be attacked, and a number of forest trees were suspected of being hosts of the insect, but the pest has now been found only on Eriodendron, and especially on young, rapidly growing trees. It is the custom when starting new farms to leave large kapok trees standing. Though these mature trees may not harbour the pest, they are a source of danger in providing young food plants for the insects. Co-operative measures are needed in dealing with this pest, since the insects migrate from badly damaged plantations to others in the neighbourhood. Kerosene emulsion was found to be the most effective spray for killing the insects. The destruction of all kapok trees in the neighbourhood of cocoa plantations, and other suitable measures, supported by legislation to enforce co-operative action, are regarded as the best means of dealing satisfactorily with this destructive pest.

Cocoa is now being largely planted in Uganda. It is stated in the *Ann. Rep. Dept. Agric., Uganda*, 1914–15, that five years ago only 16 acres had been planted, but since that time 1,852 acres have been devoted to the crop, and 1,427 acres have been prepared for planting.

Fodder Grasses.—Good results have been obtained experimentally in Nyasaland with "Moha" (*Panicum* sp.), "Teff" (*Eragrostis abyssinica*, Schrad.), and "Teosinte" (*Euchlaena mexicana*, Schrad.). These grasses are recommended for growth on large areas, the first two either alone, or in admixture, for hay; and the last for green fodder, or for making ensilage with other crops.

Of the several brome-grasses which are useful for cultivation, the most important in New Zealand is *Bromus unioloides*, H.B.K., or prairie grass. The results of trials of this grass at the Moumahaki Experimental Farm are given in an article in the *New Zealand Journ. Agric.* (1915, **10**, 313). Prairie grass will be of most value as a nutritious, succulent grass for cows during the winter months. Grazing is advised in small areas, heavily-stocked for short periods, with intervening periods of rest. A large yield may be obtained during winter and early spring by cutting the grass and occasionally top-dressing with nitrate of soda.

Oils and Oil Seeds

Bassia spp.—Attempts are being made to cultivate *Bassia latifolia*, Roxb., the source of mowra seeds, in Assam. There are nearly 1,600 healthy plants growing in the plantation at Kamrup, but they are too closely planted for future development, and the long tap-roots prevent transplantation (*Progress Rep. Forest Administration*, *Assam*, 1913–14, p. 12). The efforts made by the Excise Department to introduce the tree into other parts of Assam have not been successful, as the young plants were destroyed by animals, and could not be transplanted. Direct planting in the forest would be prohibited by the cost of fencing.

Coconuts.—Experiments with coconuts have been in progress on a small scale in Travancore since 1909 (*Rep. Dept. Agric. Travancore*, 1913–14, p. 4). A plot of ten trees which only yielded 44 nuts in 1909 showed a steady increase after manuring, and yielded 573 nuts in 1913, in which year it was manured with 10 lb. of poonac, 20 lb. of ashes, 2 lb. of bone meal, and 1 lb. of salt per tree; the cost of manuring is small, and it is estimated that a profit of Rs. 2 per tree should be obtained. A plot of about 250 trees at the Trivandrum Experimental Farm was not well cared for, and only yielded 3,998 nuts in 1912; after manuring, however, it yielded 9,857 nuts in 1913. A similar experiment carried out by the native owner of a plantation of 263 trees increased the yield from 11,300 nuts in 1911 to 19,400 in 1913. Root disease is the most serious pest of coconut palms in Travancore (*loc. cit.*, p. 8); destruction of diseased trees is generally necessary, but experiments in segregation and manuring show that there is hope of saving some of the affected trees in certain cases. Stem-bleeding disease has

also appeared in Travancore, and the remedial measures recommended by Petch, viz. cutting out and burning the diseased material, and singeing and tarring the damaged stems, have been demonstrated to owners of diseased trees. Bud rot is rarely seen in Travancore.

Twelve-year-old trees grown in Ceylon from Java seed have yielded large nuts, each giving 9 oz. of copra. A plantation of these is being made for future supply of seed nuts (*Trop. Agriculturist*, 1915, pp. 44, 288).

According to the *Report on the Trade of Brazil*, 1912–13 (*Dipl. and Cons. Repts.*, *Ann. Ser.* 5451 [Cd. 7620–61], 1915, p. 34) coconut palms are abundant along the shores of the northern states of Sergipe, Parahyba, Pernambuco, Rio Grande, and Alagôas in Brazil, but no systematic attempts at exploitation have been made up to the present. It is estimated that there are over 3,000,000 palms, yielding at the rate of 30 nuts per year. A firm has entered into an agreement with the Ministry of Agriculture to erect a copra factory capable of dealing with the produce of over 7,000 acres of plantation.

Various diseases of coconut palms in Jamaica are discussed by Ashby in *Bulletin Dept. Agric., Jamaica* (1915, **2**, 299). Bud rot has been known in Jamaica for at least a quarter of a century, and was declared an infectious disease under the Diseases of Plants Act, 1911, which compels owners to destroy diseased trees. Spraying with Bordeaux mixture is useless in the case of trees already attacked, but appears to be useful in preventing spread of the disease in plantations containing diseased trees. Firing or "flaming" of the tree is sometimes effective in early stages of the disease. Bud decay may also be caused by the attack of a weevil (*Sphenophorus sericeus*), while rhinoceros beetles sometimes eat the centres and tips of young leaves growing up from the bud.

Considerable damage to coconut and toddy palms has been caused by the palm-leaf caterpillar (*Nephantis serinopa*, Meyr.) in the Howrah, Hooghly, and Midnapore districts of Bengal (*Leaflet* No. 1, 1915, *Agric. Dept. Bengal*). The caterpillars feed on the epidermis of the underside of the leaves, causing them to wither, and in some cases leading to the death of the tree. The leaves of trees attacked should be cut off and destroyed.

Ground Nuts.—According to *L'Expansion Colon.* (1914, **8**, 174) complaints have been received during recent years as to the deterioration in quality of ground nuts from Senegal. In some cases the deterioration appears to have been very marked. At one time nuts containing three or even four kernels were common, whereas two kernels is the maximum now obtained; and in the case of nuts from Cayor many contain only one kernel. Further, careful estimations over periods of several years show that the amount of oil in

the kernels has decreased steadily. In some cases nuts of the 1913 crop were found to yield 2 per cent. less oil than those of the 1909 crop. The cause of these lower yields of oil appears to be the presence of withered and damaged seed, arising from imperfect methods of cultivation and the sowing of seed of poor quality. Chevalier has investigated this important question, and considers it essential that an experiment station should be established immediately to investigate carefully the cultivation of this crop, which is of great importance in Senegal. It will probably be necessary to establish stores for the distribution of seed of good quality, and to take other measures for the improvement of native agriculture.

Considerable quantities of ground nuts were exported from Argentina until about ten years ago, since when the exports have practically ceased (*Journ. Roy. Soc. Arts*, 1915, **63**, 679). The principal region where this crop is grown is in the northern parts of the province of Santa Fé, where oil is also produced for local use. This district has suffered from heavy rainfall of late years, which has affected the crop. In 1912, 34,668 acres were under ground nuts.

In Bombay repeated trials have shown the local varieties to be inferior to introduced varieties (*Rep. Dept. Agric., Bombay*, 1913–14). The Pondicherry variety has given the highest yields of the late-ripening, spreading kinds, and Spanish the highest yields of the early erect kinds. For varieties of small growth like Spanish, spacing of 6 in. by 4 in. is better than 9 in. by 6 in.; the Spanish variety has been found very suitable as an intercrop with Broach cotton.

Oil Palm.—Seeds of the three typical varieties of oil palm occurring in Nigeria (see this BULLETIN, 1909, **7**, 376) have been planted in the Federated Malay States (*Rep. Director of Agric., F.M.S.*, 1914, p. 21), and some have already germinated. Five-year-old palms have fruited freely, and seeds have been distributed to planters.

Para Rubber Seed.—From observations over a period of eighteen years at the Botanic Gardens, Singapore (*Gardens Bulletin, Straits Settlements*, 1915, **1**, 294), it is estimated that about 1,400 trees are required to yield 2,000 lb. of seed, or 1,200 lb. of kernels. It is interesting to note that a large crop of seed is generally succeeded by an insignificant crop at the next seeding.

Shea Nuts. — Experiments made by Hébert and Heim (*Bulletin de l'Office Coloniale*, 1915, **8**, 238) show that Shea butter (*Butyrospermum Parkii*, Kotschy) can be hydrogenated readily, the melting-point of the fat being raised from 32° C. to 70° C. by almost complete hydrogenation.

Soy Beans.—Early experiments with soy beans in Grenada were not successful, but it has now been found that this crop can be grown if the soil has been inoculated with that taken from land on which the plant has grown satisfactorily (*Interim Rep. Agric. Dept. Grenada*, 1913–14, p. 3).

Miscellaneous Oil Seeds.—The kernels of *Terminalia Catappa*, Linn., contain 52 per cent. of oil (*L'Agron. Colon.*, 1914, **2**, 172), but as the seeds only contain 9·4 per cent. of kernels they are unlikely to be of commercial importance as a source of oil.

A cucurbitaceous plant, *Ampelosicyos scandens*, Thou., known as "Voanono" in Madagascar, could probably be used as a source of oil seed (*Comptes Rendus*, 1915, **160**, i, 144). The fruits contain oily seeds, which resemble large kidney beans in appearance and are eaten by the natives. The plant is indigenous to the forests of eastern Madagascar.

The kernels of *Canarium polyphyllum*, K. Schum., yielded 69·6 per cent. of fat and a residue rich in proteins (*Zeit. f. Unters. Nahr. u. Genussmittel*, 1915, **29**, 105, and *Journ. Soc. Chem. Ind.*, 1915, **34**, 722. Cf. this BULLETIN, 1914, **12**, 545).

The oil from "I'sano" seeds from the Congo derived from *Ongokea Gore*, Pierre, is a drying oil, and, as it oxidises readily when heated with such substances as manganese dioxide, should be suitable for use in the manufacture of varnish (*Bulletin de l'Office Coloniale*, 1915, **8**, 362). Attempts to prepare rubber substitutes from this oil by treatment with sulphur or sulphur chloride were unsuccessful.

Oil from the pericarp of *Astrocaryum vulgare*, Mart., "Aouara" oil, contains an orange colouring matter similar to that of palm oil (*Elaeis guineensis*, Jacq.), and can only be bleached by methods similar to those employed for palm oil, viz. the use of oxidising agents such as potassium bichromate and sulphuric acid (*Bulletin de l'Office Coloniale*, 1915, **8**, 136).

It is claimed in a United States patent (*Spice Mill*, 1915, **38**, 666), that the objectionable taste and odour of certain oils, *e.g.* cotton-seed oil, can be neutralised by blending with other oils, of which ground-nut oil appears to be specially suitable. It is said that an addition of 3 per cent. of this oil to ordinary "deodorised" cotton-seed oil is sufficient.

A machine named the "Downie" nut-cracking machine has been designed by Wotherspoon (*Implement and Machinery Record*, 1915, **40**, 1257) for cracking cohune nuts. The machine is driven by a 5 H.P. oil engine, and consists essentially of a depulping device for removing the fibrous pulp from the fruits, combined with a centrifugal nut-cracker and a riddle for separating the kernels from the broken shells.

Waxes.—Hébert and Heim have published information relating to waxes derived from *Vohemaria Messeri*, Buchenau (N.O. Asclepiadaceae) and from two species of *Euphorbia*, *E. xylophylloides*, Brogn., and *E. stenoclada*, Baill. (*Bulletin de l'Office Coloniale*, 1915, **8**, 96, 133). The wax can be extracted either by beating the dried plants cut into small pieces on a cloth, the detached powder being melted in boiling water, or by immersing the plant in boiling water. A plant of *E. xylophylloides* of normal size is said to give about 2 lb. of wax by the latter method and nearly 4 lb. by the former, while the other species of *Euphorbia* yields somewhat less. Six small plants of *Vohemaria Messeri* yielded nearly 7 oz. of wax; unfortunately the weights of the plants taken are not quoted. A native can prepare about 9 to 11 lb. of wax in a day. The authors state that these waxes resemble China and Japan waxes, but the figures they quote are in better agreement with those given by carnauba and candelilla waxes. All these waxes are of a brown colour. A number of methods usually employed for bleaching waxes were tried without success, but it was found that the colour can be improved by dissolving the waxes in a mixture of acetone and benzene in which the colouring matter is less soluble; a further improvement in colour is effected by treating the solution with animal charcoal.

Rubber

Hevea brasiliensis.—Experiments with cover-crops have been made in the Federated Malay States (*Rep. Director Agric.*, 1914, p. 21). *Vigna lutea*, A. Gray, *Pueraria phaseoloides*, Benth., and *Phaseolus calcaratus*, Roxb., suffered from insect attack. *Centrosema Plumieri*, Benth., a strong creeper, was useful in preventing wash on hilly ground and in checking weeds on flat land. *Dolichos Hosei* was found to be suitable for either flat or hilly ground. *Cassia mimosoides*, Linn., *C. patellaria*, DC., and *Crotalaria alata*, Buch.-Ham., appeared to be suitable green manures; but *Clitoria cajanifolia*, Benth., and *Tephrosia Vogelii*, Hook., are possibly of too vigorous growth.

Experimental cultivation has been carried out on the Castleton Estate by several different methods. The results showed that during the first year surface weeding was preferable to the growth of cover-crops, as the cost was less and the trees made a greater increase in girth.

Experiments have been made on the use of explosives for breaking up sub-soils in rubber plantations. The method was found to be most effective on clayey soils (*loc. cit.*, pp. 21 and 24). Rubber trees on a dynamited plot showed a satisfactory increase in girth over those on a control plot.

The *Gardens Bulletin, Straits Settlements* (1915, **1**, No. 8),

deals entirely with "the treatment to which Para rubber trees in the Botanic Gardens, Singapore, have been subjected. An interesting historical summary of the early distribution of *Hevea brasiliensis* is given, and a detailed account of all the tapping experiments and a number of illustrations are included.

The Variability of Plantation Para Rubber.—In a series of papers published in the *Agric. Bulletin, Federated Malay States* (1915, **3**, 175, 218, 397), Eaton and Grantham discuss the results of vulcanisation experiments carried out in the Federated Malay States on samples of rubber prepared in various ways.

In the first paper the results of vulcanisation tests on a number of experimental and commercial samples of Para rubber are dealt with. The results are in the main similar to those obtained at the Imperial Institute with rubbers prepared by similar methods in Ceylon, and tend to show that "first latex" rubbers yield products on vulcanisation which usually differ only slightly in physical properties (strength and elongation). They also confirm the results of previous workers in indicating a wide variation in the length of time required to cure different samples of plantation rubber so as to obtain the best results. The samples tested by Eaton and Grantham required from 60 to 195 minutes at 140° C.

The suggestion is made that "the rate of cure is due to the presence of some non-caoutchouc substance in the latex, possibly the proteins or some other constituent, or to some degradation product derived from these substances, which acts as a catalyst and accelerates the rate of cure." The authors were led to this opinion by finding that rubber prepared in thick slabs cured much more quickly than rubber prepared from the same latex in thin sheets. It is concluded that the cause of variation in time of cure is to be sought in the probability that, on coagulation of the latex, more of the non-caoutchouc constituents are retained by thick slabs than by thin sheets. It is suggested that the substances which influence the rate of cure are amines, due to decomposition of proteins, but no experimental data are quoted in support of this view. Further experiments are to be made, and the results will be of interest.

In the second paper the effect of additional crêpeing, of excess of acetic acid, and of the addition of sodium bisulphite on the rate of cure, are considered. Specimens which had been crêped from 5 to 35 times or very heavily worked on a crêpeing machine were tested, and only in the case of excessively worked rubbers was the rate of cure retarded, and then only to a slight extent. Rubber prepared by the addition of 15 oz. of 5 per cent. acetic acid per gallon of latex cured somewhat more slowly than

rubber prepared from the same sample of latex by the addition of 3 oz. of acetic acid per gallon. The addition of 2 oz. of 5 per cent. sodium bisulphite per gallon of latex had no effect on the rate of cure in the case of the crêpe rubbers.

In the last paper the authors show that the effect of each stage in the preparation of a thin crêpe is to retard the rate of cure. A number of samples of crêpe prepared on successive days on the same estate showed fairly uniform results as regards time of cure and physical properties; the latter, however, appear to be somewhat poor for a "first latex" crêpe.

Manihot Species.—The cultivation of *Manihot Glaziovii* at the agricultural station of Bokala in the Belgian Congo is described by Janssens (*Bulletin agricole du Congo Belge*, 1914, **5**, 416). Manihot was planted in 1900–1903, but the station was abandoned in 1905, and not reoccupied until 1908. Since that year considerable plantations of Manihot have been made. In 1914 there were 855 acres, carrying nearly 220,000 trees, of which about 62,000 would be fit for tapping in 1915. The Lewa method of tapping is used. A number of different coagulants have been tried, including those locally obtainable, such as an aqueous extract of the leaves of *Cissus adenocaulis*, but a mixture of acetic and carbolic acids proved to be the cheapest. Trees at Bokala have been found attacked by several diseases, but only one, a root-rot, appears to be so serious as to necessitate destruction of trees.

Fibres

Hibiscus cannabinus.—In 1911, some new varieties of *Hibiscus cannabinus* were described by Albert Howard and Gabrielle L. C. Howard (this Bulletin, 1911, **9**, 413). One of these varieties, known as "Type 3," has been cultivated at Pusa during the last five years for the production of fibre, and the results of these trials are described by the above-mentioned authors in an article entitled "An Improved Fibre Plant" (*Agric. Journ. India*, 1915, **10**, 224). The new type is characterised by great robustness and vigour. It is taller than the ordinary crop and is able to grow and ripen seed under conditions in which the other varieties fail to do so. As cross-fertilisation is very liable to occur between Hibiscus plants of the various types, the seedlings of the new variety were carefully inspected, and all plants which were not true to type were weeded out. A sample of fibre, prepared by the usual method of retting, was submitted to Messrs. Wigglesworth & Co. of London, who reported that the product was of excellent growth, 10–12 ft. long, of an exceptionally light colour, well cleaned, and of good strength. The fibre was regarded as worth £18 per ton,

when Bimlipatam jute was quoted at £12 10s., and Bengal first marks at £17 per ton. It is proposed to introduce the cultivation of this variety into several parts of India and, as a commencement, arrangements have been made to grow it on several estates in Bihar.

Paper-making Materials.—In an earlier number of this BULLETIN (1914, **12**, 135) reference was made to the work of Mr. W. Raitt in connexion with the value of the grasses of the Indian forests for paper-making. In the *Ann. Rep., Industries and Commerce Committee of the Mysore Economic Conference*, it is stated that, in the Mysore District, eight forests of aggregate area 456 square miles have been explored. These forests may be regarded as consisting of two parts, one with Nanjungud as a centre, and the other with Manchegowdanahalli on the Mysore-Manantoddy road as a convenient site. In the former area, about 31,000 tons of grasses, suitable for pulp, are available per annum and could be delivered at Nanjungud at Rs. 15 (£1) per ton. Approximately the same quantity could be obtained in the second area, but the cost of delivery at Manchegowdanahalli is only about Rs. 9 (12s.) per ton. This latter area could also provide an annual supply of 15,000 tons of bamboos (*Dendrocalamus strictus*, Nees) from the forests on the banks of the Kabana. Unfortunately, however, the localities mentioned are badly situated with respect to manufacturing facilities. Manchegowdanahalli is 38 miles from Mysore and probably would not afford a sufficient supply of fuel. In the Shimoga forests the case is different, and it has been found that 28,500 tons of thin bamboo (*Dendrocalamus strictus*) could be landed annually at Shimoga at a cost of Rs. 9.4 (12s. 4d.) per ton. Firewood can be obtained at Rs. 5.8 (7s. 4d.) per ton, and ample water is available from the Tungabhadra.

Silk.—A monograph on the Silk Industry of Assam, by Rai Bhupal Chandra Basu Bahadur, has been published recently by the Assam Secretariat Printing Office at Shillong. It gives a detailed account of the rearing of the different kinds of silkworms, the reeling and spinning of the silk, and the preparation of the yarn for weaving, and reference is also made to the diseases affecting the worms. The present position and prospects of the industry are discussed and suggestions are made for effecting improvements in various directions. There are three species of silkworm reared in Assam, viz. the mulberry silkworm (*Bombyx mori*), the eri worm (*Attacus ricini*), and the muga variety (*Antheraea assama*). An account of the last two insects and the methods of rearing them has been given in this BULLETIN (1915, **13**, 87).

Mulberry silk is produced to such a small extent as to be of little importance, and the rearing of the worm is restricted by custom to a particular caste of Hindus, the

Katonis or Jugis, who inhabit certain parts of the Brahmaputra Valley. The Katonis are a low caste, and are regarded with contempt by the rest of the population. They are at present animated by a desire to improve their social status, but are not allowed to have any social intercourse with the better classes of Hindus unless they relinquish the rearing of mulberry silkworms. For this and other reasons, especially losses which occur from diseases, the mulberry silk industry is gradually declining. It is considered that something might perhaps be done to revive it by supplying improved races of the silkworms, teaching the rearers how to combat disease, and introducing the culture among people with no social or religious prejudice against the industry. The Agricultural Department attempted something on these lines a few years ago at Shillong, but have not yet met with any appreciable success. The Roman Catholic missionaries at Shillong are also endeavouring to encourage the industry.

The rearing of the eri silkworm is more popular than that of either of the other kinds, and is carried on to some extent in nearly every village in the Assam Valley. There are no social restrictions in this case, but every class of people is permitted by custom to engage in the work. The prospects of this branch of the silk industry seem very hopeful, and there is an increasing export of the cocoons, cloth, and thread to other parts of India, and a demand has arisen for the cocoons from European spinners. Unfortunately, however, the cocoon trade is seriously threatened by the cultivators leaving some of the chrysalides in the cocoons in order to increase the weight, with the result that complaints are received from spinners who state that, unless the chrysalides are removed, their machinery is liable to be injured and the quality and colour of the yarn are deteriorated.

The rearing of the muga silkworm is peculiar to Assam, and is carried on by all castes and classes of the people. The industry has disappeared from certain districts where it once flourished, but still continues to be of importance in some of the less progressive parts of the Assam Valley. A considerable quantity of the silk is exported to Bengal and other parts of India. The culture of this variety is in a stationary condition, and does not appear capable of much development. There is no demand for the silk outside India, and the product is far too expensive for the European market. Even in India many manufacturers have abandoned its use in favour of imported silk. The silkworm is very susceptible to diseases, and if some means could be found for preventing disease the industry might, perhaps, be extended and the silk become cheap enough to compete with other kinds.

In the *Rep. Dept. Agric., Travancore*, 1913–14, it is

stated that experiments have been continued at the Government silk farm, and successful results have been obtained with eri silk and with mulberry silk of the Mysore and Bengal varieties. Large quantities of mulberry cuttings have been distributed to the people, and several plantations have been established in different parts of the country. The officers of the farm are endeavouring to create an interest in the industry by giving lectures on the advantages to be derived from sericiculture, and by affording practical help to new rearers. The cultivation of eri silk is handicapped by the difficulty of growing the castor-oil plant on a large scale without heavy manuring at prohibitive cost. It has been proved that mulberry silk culture can be undertaken with profit in Travancore from June to January, but during the rest of the year the heat is so great and the rainfall so deficient that neither the silkworm nor the mulberry tree can thrive satisfactorily. These observations are in accord with the experience gained at the Salvation Army's silk farm at Bangalore.

According to the *Rep. Agric. Dept., Bengal*, 1913–14, an attempt is being made to develop a type of silkworm which would yield cocoons superior to the native Bengal kinds and which would not undergo degeneration on account of the climate. It was found some years ago that cross-bred worms, although superior in the first generation to the native varieties, rapidly deteriorate owing to the unfavourable conditions which prevail particularly from July to October. It has therefore been proposed to keep the seed cocoons in the hills during this period, and this scheme is now under trial. It is considered, however, that the increased cost may perhaps render this plan impracticable.

The production of mulberry silk in Bengal and other parts of India has declined to such an extent that the opinion has been expressed that the industry will disappear in the course of a few years unless some measures are taken to improve its condition. The chief causes of the decline are the prevalence of diseases and pests, and the lack of an organisation for supplying disease-free eggs to the rearers. In order to revive the industry, it is essential that a better class of silkworms should be introduced either by (1) the introduction of some suitable exotic variety, (2) cross-breeding between both indigenous and foreign races, or (3) by improving the indigenous races by selection. Breeding and selection experiments are being made at the Agricultural Research Institute, Pusa, and the first report has been published recently by the Institute as *Bulletin* No. 48, 1915. Interesting results have been obtained, but these are not yet sufficient to enable any very definite conclusions to be drawn with regard to the brood characters of the hybrid silkworm races. The *Bulletin* also gives a short description of the different races of mulberry

silkworms now reared in India, and an account of former efforts to improve them.

Cotton.—In the *Rep. Dept. Agric., Burma, for the year ended the 30th June*, 1914, it is stated that the study of cotton has now been taken up seriously by the Department. Special attention is being given to the crop at the Tatkôn farm in the Yamèthin District, and at the Padu farm in the Sagaing District, and seed farms are to be established in the districts of Pakkôku, Myingyan, and Thayetmyo. It is hoped that the plant-breeding experiments now being carried out will lead to the production of a local variety, greatly superior both in yield and quality to the cotton at present grown. An encouraging sign for the future of the cotton industry is the desire of the cultivators for the formation of co-operative ginneries. At present the grower is unable to recover the seed from his crop, as he is bound to sell his seed-cotton to middlemen, who mix it with that purchased from others. Seed for sowing has to be obtained from the ginneries at Myingyan, which can only supply an average sample of the total crop received by them, but by the creation of small co-operative ginneries this difficulty would be surmounted. Attention is being devoted to the question of irrigation, and the introduction into certain tracts of a system of tube-wells worked by oil engines is under consideration.

FORESTRY AND FOREST PRODUCTS

Forests of Newfoundland.—Interesting information relative to the Newfoundland forests is given in the *Minutes of Evidence taken in Newfoundland in* 1914, *Dominions Royal Commission* ([Cd. 7898], 1915, pp. 54–70). The best timbered areas of the island are, generally speaking, found in strips about 1 to 2 miles wide, along the larger rivers and their tributaries, and round the lakes. The forests consist chiefly of spruce, fir, white pine, white and yellow birch, and tamarack or juniper. The two first-named predominate, but in some sections a considerable amount of good pine is to be found. The largest proportion of birch is on the west coast. All the known timbered areas of the island, except those within 3 miles of the sea-shore, are held under licence by private parties or by companies. The holder of such a licence has the right to cut timber for a term of 99 years at a fixed annual rental, and he must erect and operate a sawmill of a certain capacity within three years of the date of the licence, or spend a certain sum within five years of the date of the licence on the erection of a building and plant for the manufacture of pulp and paper. A royalty is payable to the Crown on all timber cut, except that manufactured into pulp and paper. The licensee is under no obligation to

reafforest the areas cut, and no experiments in re-afforestation have yet been made by the Department of Agriculture. The largest lumbering operations carried on at present are concerned chiefly with the production of timber for the manufacture of paper and pulp, and memoranda furnished to the Commission by representatives of the companies contain much valuable information as to the industry. At one time a considerable quantity of sawn timber was exported, principally to South America, but the exports have declined in recent years, owing to the increased attention devoted to the paper and pulp industry.

Since the outbreak of war considerable attention has been devoted to the cutting of timber suitable for pit props (see this BULLETIN, 1915, **13**, 137), and it has been stated recently that during 1915 approximately 50,000 cords of such timber were shipped from Newfoundland to British ports, whilst it is expected that, if sufficient labour can be obtained for cutting, the exports in the coming season will approach 150,000 cords.

Osier Cultivation.—*Farmers' Bulletin* 622, 1915, *U.S. Dept. Agric.*, is devoted to a description of the methods of growing and preparing willows suitable for basket-making. It deals with the selection of the site for a plantation, the most suitable soils, the different varieties adapted for cultivation in the United States, propagation, planting, manuring, harvesting, methods of peeling the cut stems and marketing the produce. Although written specially for the American grower the *Bulletin* contains much information of value to all interested in osier cultivation.

Insect Pests of Forest Trees.—One of the most injurious insects to pine forests in Europe is a small orange-red moth (*Evetria buoliana*, Schiff.), the larva of which eats out the new buds and kills or deforms the young twigs of pine trees, with the result that their timber value is seriously and permanently lowered. This European pine-shoot moth has within recent years been accidentally introduced into the United States, and has already become established in several widely separated localities. So far the insect has been confined to nurseries and private parks and has not spread to the native pines, but, as it attacks indiscriminately all species of pine, it may, if not checked in its early stages, become a serious menace to the American pine forests. A general account of the insect, including its present distribution in the United States, its life-history, the character of the injury caused, its natural enemies, methods of control, etc., is given in *Bulletin* No. 170, 1915, *U.S. Dept. Agric.* It appears that the only method of combating the pest is to cut off and burn all infested buds and twigs, preferably in the autumn and winter so as to

enable the secondary set of buds to develop in the following spring.

In the *Ann. Prog. Rep., Forest Administr., Bengal*, 1913–14, p. 8, a description is given of a serious pest of "sal" trees (*Shorea robusta*, Gaertn.), which has been recently found to cause considerable damage in the Jalpaiguri and Buxa Divisions of Bengal. The adult insect, which proves to be a new species of Scolytid beetle, *Diapus furtivus*, Sampson, bores into the trunk just below the crown branches and makes galleries in the sapwood in which the larvæ live. The heartwood is not attacked to any extent, and the value of the timber from trees killed by the beetle is not affected, but the premature death of small trees causes much loss. The only method of controlling the pest at present recommended is to fell attacked trees and to remove and destroy the bark and sapwood.

Timbers

Some Indian Timbers.—The series of notes on Indian timbers referred to previously in this BULLETIN (1913, **11**, 534) is continued in *Forest Bulletins* Nos. 27, 28, 29, which deal respectively with blackwood or rosewood of Southern India (*Dalbergia latifolia*, Roxb.), dhauri (*Lagerstroemia parviflora*, Roxb.), and sundri (*Heritiera minor*, Lam.). In each case an account is given of the distribution and habitat of the tree, the character, properties, and uses of the timber and minor products, the reproduction and rate of growth of the tree, together with notes on distribution and extraction in different provinces, and statistics of outturn and prices. As in the case of the previous *Bulletins* a longitudinal section of each timber is included.

Blackwood or rosewood occurs over a large area of Peninsular India, but is rare in the north and is nowhere abundant. It is most common along the Western Ghats, where it reaches its largest size, trees of 20 ft. in girth and up to 90 ft. in height, with a clear bole of 70 ft., being found in the semi-moist deciduous forests of South Coimbatore, Madras. The heartwood is of a dark purple colour with rather conspicuous longitudinal black streaks. It takes a very fine polish and is largely used in the manufacture of high-class furniture as well as for internal decoration, panelling, doors, etc. It is stated to be one of the best timbers known for gun-carriage wheels, and is also used by the Ordnance Department in India for a great variety of other purposes. The timber has given excellent results as railway sleepers, but its high price prevents its being extensively used for this purpose. Rosewood is shipped to Europe in small quantities from the Divisions of Central Coimbatore, Eastern Kanara, and Nilgiri, and there was formerly a considerable trade from the South Malabar Division.

Dhauri is fairly common in certain parts of the Sub-Himalayan tract from the Sutlej eastwards, and is also found in Assam, Lower Bengal, Orissa, Central India, Northern Bombay, and Burma. The wood is very hard and of a grey or greyish-brown colour. It is not very durable, especially in exposed situations, and is liable to the attack of white ants. It is used in constructional work for house-building, in the making of carts and tool-handles, and has been tried for railway sleepers and for opium chests with good results.

Sundri is found in the tidal forests, which lie on the inner side of the mangrove belts. In Bengal, such forests occur in the Sunderbans and along the Chittagong coast; and in Burma, along the coast of Arakan and Bassein and round the islands off the South Tenasserim Division. The heartwood is brown-red to dark red in colour, very hard, close-grained, elastic, very durable and one of the strongest of Indian timbers. The timber is extensively used locally in boat- and carriage-building, for agricultural implements, and for furniture and constructional work. Its use for the last-mentioned purpose might be considerably extended, but in Burma there is a preference for the standard timber, teak.

Gums and Resins

Rosin Industry in Spain.—The production of turpentine products is an important industry in Spain (*Revista de Montes*, 1915, **39**, No. 111, p. 3). The yield of rosin was estimated to be 17,500,000 lb. in 1888; in 1912 the output of this industry was: turpentine oil, 10,959,571 lb., rosin 37,082,445 lb., various products 69,426 lb. The greater part of this output is exported, the export figures published in the Spanish Customs Returns for 1912 being: turpentine oil 7,237,064 lb.; rosin 25,067,737 lb. The chief countries of destination are: Germany, the United Kingdom, Switzerland, Australia and the United States, the last-named country in spite of the fact that its own production is about twenty times as great as the Spanish output.

Lac.—The Indian lac insect (*Tachardia lacca*) has, after many unsuccessful attempts, been established in Ceylon (cf. this BULLETIN, 1912, **10**, 508; 1913, **11**, 360, 696). According to *Trop. Agric.* (1915, **44**, 259), trees have been inoculated at Matale, Kurunegala, Colombo and Kandy, and lac has been developed satisfactorily in all these localities. In order to afford the villagers information on the methods of lac cultivation, it has been decided to issue a leaflet in the vernacular.

Pontianac Resin.—Attempts are being made to find new uses for this resin, and in particular to find the conditions under which satisfactory solutions can be obtained (cf. this

BULLETIN, 1915, **13**, 359). An account of an investigation of its properties from this point of view is given in *Journ. Indust. Eng. Chem.* (1915, **7**, 747). The best commercial solvent, of a number that were tried, was 90 per cent. benzene. A sample of the resin had a melting-point of 126° C. After being heated in open vessels to temperatures from 204° C. to 316° C., for periods ranging from one to twelve hours, during which various volatile substances were evolved, the resin became hard and clear, and had a melting-point of 77-78° C., whilst heating from four to six hours at 343° C. under a short, air-cooled, reflux condenser converted it into a mass which remained plastic at ordinary temperatures. In all cases, the resin which had been heated was somewhat more soluble in organic solvents than the original resin, and had a higher iodine value. Films of the plastic resin deposited on glass plates were dark and clear, and were hardly affected by immersion in 5 per cent. caustic soda solution for five days.

Tanning Materials

Guara.—This material consists of the ground fruits of a species of Caesalpinia from Central and South America, and is closely allied to divi-divi derived from *C. coriaria*. According to Dr. T. Callan (*Journ. Soc. Chem. Ind.*, 1915, **34**, 645) microscopical examination showed it to consist almost wholly of the inner part of the fruit wall. Analyses of various samples carried out during the last two years by the official method of the International Association of Leather Trades Chemists show that the material has a fairly constant composition, the range given by typical analyses being as follows: tannin 43·5–48·4 per cent., extractive matter (non-tannin) 23·1–25·8 per cent., insoluble matter 17·7–22·0 per cent., moisture 9·0–10·7 per cent. It is stated that guara is free from liability to give excessive fermentation and yields a soft, well-filled leather, resembling one tanned by means of gambier. Its most characteristic features are its acid-forming properties and the light colour and mellowness of the tanned product; when used in admixture with untreated quebracho extract it has been found to have a very favourable influence on the colour of the leather.

Guara extract gives a dark-coloured infusion, and is stated to be inferior in all respects to the raw product; it has not been favourably received by British tanners, and is no longer imported into this country.

ECONOMIC MINERALS

Antimony Ore.—According to the *Dip. and Cons. Rep. for* 1914 *on the Trade of Changsa* (*Annual Series*, No. 5489 [Cd. 7620–99], 1915) the outbreak of the European war gave a considerable stimulus to the mining of antimony ore in this consular district, which covers the province of

Hunan. This province has been an important contributor to the world's supply of antimony for many years. Prior to the outbreak of the war, the output of the pure metal, as refined by the Hua Ch'ang Company of Changsa, was controlled and marketed in London by a British firm under a time contract. After the outbreak of the war, however, the Chinese refiners took advantage of temporary banking difficulties to denounce the contract and cornered the output. There was a large demand for antimony in Japan, Russia, America, and the United Kingdom, and prices rose rapidly. The price of regulus on the London market at the outbreak of war was about £25 per ton. At the beginning of December it had risen locally to over £52 per ton (f.o.b. Hankow), and to between £60 and £70 per ton by the end of the year. The output during 1914 as compared with 1913 is shown in the following table:

	1913. *Tons.*	1914. *Tons.*
Regulus (metal equivalent) . . .	2,106	2,735
Crude " " . . .	6,914	9,816
Ore " " . . .	4,169	4,672

In addition to this there was an output of 2,553 tons of "ash," equivalent to 255 tons of metal in 1914, compared with 6,283 tons of "ash" in 1913.

The output of the Hua Ch'ang Company's refinery averaged a little over 200 tons a month during 1914; but the plant has been extended, and the company has now its own office in New York.

Asbestos and Mica.—According to the *Report on Mining Operations*, *Quebec*, 1914 (*Mines Branch*, *Quebec*, 1915) the asbestos production of Quebec during the year 1914 amounted to 107,401 tons, valued at $2,895,935, compared with 136,609 tons, valued at $3,830,504, during 1913. This decrease of 21 per cent. in tonnage and 24 per cent. in the value of the output represents a severe temporary check to an important industry that has grown continuously for many years, the output having increased from a tonnage of 29,261, and a value of $916,970 in 1903 to the tonnage and value stated above for 1913.

The outlook for a large production during the early part of 1914 was very promising, but as a consequence of the outbreak of the war most of the producers were compelled to reduce or discontinue their mining operations, owing to the fact that Germany was a very important market for Quebec asbestos. It is stated, however, that since the middle of January 1915 a great improvement has taken place in the asbestos market, and the mines during the early part of the year resumed their activity.

Mica mining in Quebec was also adversely affected by the war, as shown by the fact that the mica output for the year had a value of only $67,278, compared with $117,038

during 1913. The prices of mica were satisfactory and the demand good during the early part of the year, but there was little or no demand after the outbreak of the war. As a consequence of this, most of the mines were closed, and the mica had to be sold at a loss.

An interesting feature of the year was the production of substantial quantities of excellent mica at a mine situated some 18 miles below the city of Quebec, at Petit Pré, about 2 miles inland from the St. Lawrence River. The industry in previous years had been limited almost entirely to the region of the Gatineau and Lièvre rivers. The mica at Petit Pré occurs in a vein of pyroxenite traversing gneiss, and its mode of occurrence is thus similar to that of the Lièvre-Gatineau region. The mica is rather dark, but a large quantity of good material has been extracted.

This occurrence of mica is of special interest as showing the existence of a pyroxenite belt in the region of Quebec city, and it seems not improbable that further prospecting in this area will lead to other discoveries of deposits of useful mica.

Corundum.—The Government Geologist of the Federated Malay States reports that the corundum which occurs in the form of boulders and pebbles on the east side of the Kinta valley has recently been utilised for boring purposes (*Supplement to the F.M.S. Government Gazette, Kuala Lumpur*, June 11, 1915). A specimen was broken into angular fragments of about ⅛ in. diameter. Six of these fitted in a crown gave results that compared favourably with a calyx head and chilled shot. Rocks consisting of shale and coal were bored. The average rate of boring in shale was 1·2 ft. per hour, and that in coal and carbonaceous shale 1·8 ft. per hour. One setting of the crown lasted for about 200 ft., and a good core was obtained where the rocks were firm. For an account of the Kinta valley corundum, see "The Commercial Utilisation of Corundum from Perak, Federated Malay States" (this BULLETIN, 1904, **2**, 229).

Diamond.—The discovery of minute diamonds in chromite occurring in the Tulameen district of British Columbia (see this BULLETIN, 1912, **10**, 170) has led to the examination of the chromites of the Black Lake district in Quebec. According to the *Report on the Mining Operations, Quebec*, 1914 (*Mines Branch, Quebec*, 1915), a specimen from this district, consisting of granular chromite and some greyish serpentinous material, has been examined by R. A. A. Johnston of the Geological Survey, and found to contain diamonds.

The residue of diamonds obtained by chemical treatment of the crushed specimen amounted to about 0·06 per cent.

of the material. The diamonds are extremely small, and appear to the naked eye as mere dust particles, though under the microscope they are seen to be perfectly transparent and well crystallised, the octahedron being the common form. The crystals fluoresce when exposed to radium emanations, and this test is regarded as proving conclusively the identity of the mineral. The diamonds are obviously too small to be of value as gems, but the occurrence is regarded as important. A fuller examination of the rocks and gravels of the district will be necessary before it can be ascertained whether or not diamonds of commercial value exist in them.

Mica.—A note on mica in Quebec is given on p. 661.

Monazite.—According to the *Federated Malay States Chief Secretary's Annual Report for* 1914 (*Supplement to the F.M.S. Government Gazette, Kuala Lumpur*, June 11, 1915) the Government Geologist reports the discovery of small quantities of monazite *in situ* in a disused quarry south of Lenggong. It was found at the junction of a pegmatite with limestone, and was obtained by crushing the rock and panning the crushed material. It is believed that the monazite is disseminated in the pegmatite, though some of it may have come from the limestone. Monazite has been known for some time to occur in detrital deposits in the Malay Peninsula, but this is stated to be the first time it has been obtained there from the parent rock. For an account of the monazite occurring in the detrital deposits of Malaya, see "Occurrence of Monazite in the Tin-bearing Alluvium of the Malay Peninsula" (this BULLETIN, 1906, **4**, 301).

Petroleum.—In *Bulletin* No. 65, *Geol. Surv., Western Australia* (Government Printer, Perth, 1915), H. P. Woodward, Assistant Government Geologist, deals with the reputed petroliferous area of the Warren River District in the South-West Division of the State. This district received attention some years ago as a supposed oil-field, owing to various optimistic reports which appear not to have been well founded.

As long ago as 1902, however, the Government Geologist examined the district and reported that no hope could be reasonably entertained that the district would become an oil-producer of any importance; but, in spite of his judgment, optimistic views have lately been entertained in certain quarters.

Under these circumstances, and in view of the interest that has been taken recently in Australia's petroleum resources, the Assistant Government Geologist has carried out an examination of the district. He concludes his report very confidently in the following terms: (*a*) That there are absolutely no indications of petroliferous deposits *in situ* in this portion of the State; (*b*) that the geological

formations are in no way favourable to such; and (*c*) that the entire mass of so-called evidence adduced in favour of the existence of such deposits appears to be directly traceable to either company promoters or other interested persons in their employ.

These strictures are rather severe, but a reading of the case, as presented in detail with fairness by the Assistant Government Geologist, makes it clear that they are not too strong. The optimists appear to have mistaken the familiar scum of hydrated iron oxide for indications of oil, and have regarded peaty masses as "bituminous rock"; they have also laid undue stress on the discovery of pieces of asphalt (probably erratics) that are distributed along the southern coast of Australia.

The Western Australian Survey Officials have come to much the same conclusion regarding the asphalt blocks on the coast as that arrived at by the Government Geologist of South Australia (see this BULLETIN, 1913, **11**, 517). They regard this asphalt as "a foreign substance thrown up by the sea," and as giving no indication of the occurrence of petroleum in the region where it occurs.

The re-investigation of the Warren River District thus bears out the Government Geologist's first report, and seems to show conclusively that no considerable deposit of petroleum is likely to be found in this district.

The Mines Branch of the Canadian Department of Mines has issued the first of two volumes dealing with the "Petroleum and Natural Gas Resources of Canada," by F. G. Clapp and others (*Publication* No. 291, *Ottawa, Govt. Printing Bureau*, 1914). This volume deals with Technology and Exploitation, and treats the subject widely. The topics dealt with include the history, occurrence, properties, and production of petroleum and natural gas; methods of drilling, pumping, storage, and transportation; the utilisation of petroleum and its products; and the conservation of oil and gas resources. The second volume promised will deal specially with the occurrences of petroleum and natural gas throughout the provinces of Canada.

Another publication relating to petroleum recently issued by the Mines Branch of the Canadian Department of Mines is a "Preliminary Report on the Bituminous Sands of Northern Alberta," by S. C. Ells (*Publication* No. 281, *Ottawa, Govt. Printing Bureau*, 1914). The bituminous sands of Alberta, or "tar sands" as they have been more commonly named, have long been known. They outcrop at numerous localities along the Athabaska River and its tributaries, for many miles north and south of McMurray and in other places.

The bituminous sands are on the horizon of the Dakota sandstones (Cretaceous). They lie unconformably on Devonian limestones, and are succeeded by soft shales,

sands, and surface drift. These overlying beds appear to form a thick overburden, and will present a serious obstacle to exploitation in many places if this is attempted.

A number of analyses of samples of bituminous sand from the McMurray District show percentages of bitumen varying from 8 to 20. A sample of crude bituminous sand from the east bank of the Athabaska River, half-a-mile south of McMurray, had a specific gravity of 1·75, and gave the following percentage results on analysis:

Sand	80·2
Bitumen soluble in carbon disulphide	18·5
Moisture	1·3

The bitumen extracted by carbon disulphide had a specific gravity of 1·018 at 25° C.; on analysis it was found to contain:

Fixed carbon	7·23 *per cent.*
Sulphur	4·85 ,,
Bitumen soluble in 88° naphtha	78·2 ,,
Ash	trace
Unsaturated compounds soluble in 88° naphtha	60·4 ,,

The number of outcrops of bituminous sand observed in the McMurray District were 247, and it is clear that there is a large amount of bituminous sand available. Owing to the heavy overburden, however, and defective quality in the material of some of the outcrops, it is considered that 80 per cent. of these exposures are of no commercial significance. Transport difficulties reduce the number of workable outcrops still further. It is thought, however, that certain of the outcrops of bituminous sand-rock should lend themselves to development on a commercial scale for use in the manufacture of paving material.

Phosphates.—In the *West Indian Bulletin* (1915, **15**, 22) Dr. H. A. Tempany gives a report dealing with the island of Redonda. The island is situated in latitude 16° 55′ North, longitude 62° 16′ West. It is a mile in length and a third of a mile wide at the broadest part, rising at its highest point to about 1,000 ft. above sea-level. The island is chiefly remarkable for the occurrence in it of aluminium phosphate—the so-called Redonda phosphate. The phosphate occurs as veins in the volcanic rock of which the island is composed. The veins vary in thickness from a few inches up to about 2 ft. The phosphate is fine-grained in texture and varies in colour.

The different varieties can be roughly classed as pale creamy, black and red varieties. Three typical samples gave the following results on analysis:

	Dark-coloured variety. *Per cent.*	Red variety. *Per cent.*	Pale-coloured variety. *Per cent.*
Water	16·05	21·56	19·17
Phosphoric acid	27·07	38·60	33·20
Silica	13·87	3·20	17·80
Alumina and iron oxide	23·76	26·44	23·04
Lime	nil	nil	nil

The red variety is regarded as the most valuable, and the above analyses show it to be the variety containing the largest percentage of phosphoric acid. The state of combination of the phosphoric acid (with aluminium) renders the material unsuitable for the manufacture of superphosphate, and the chief application of it appears to be for use directly as a manure in a finely ground condition.

The phosphate is excavated from open quarries and transported to the shore for shipment by means of a cableway by bucket conveyers, each of which is capable of carrying half a ton of phosphate. The length of the cable-way is 750 ft., and it rises to a height of 600 ft. The phosphate appears to be worked with greater difficulty now than formerly, perhaps owing to a tendency of the veins to become thinner as they are traced downward. The phosphate is stored on the sea front until sufficient has been accumulated for shipment. No shipment appears to have been made since 1912, but at the time of Dr. Tempany's visit some 1,234 tons were ready for export.

Rutile.—"The Rutile Deposits of the Eastern United States," by T. L. Watson, is the subject of *Bulletin* 580—O, issued by the United States Geological Survey (Washington, Government Printing Office, 1914). Rutile is widely distributed in all classes of rocks, igneous, sedimentary, and metamorphic; but it is chiefly from igneous rocks and pegmatites that the rutile of commerce is obtained. The chief localities where it has been mined are (1) the Amherst-Nelson and Hanover-Goochland areas in Virginia, U.S.A.; (2) Bay St. Paul, in Northern Quebec, Canada; (3) Kragerö, in Norway; and (4) an area near Mt. Crawford, 25 miles north-east of Adelaide, in South Australia.

The workable deposits of the Amherst-Nelson area include two different types of deposit, namely (1) syenite (formerly called pegmatite), in which the rutile occurs as disseminated grains and segregations; and (2) nelsonite, a dyke-like rock composed normally of apatite and ilmenite, though a variety containing plenty of rutile is also found.

The syenite type contains a variable amount of rutile varying from sparsely disseminated grains up to segregation masses, which may constitute as much as 30 per cent. or more of the rock, with an average of 4 or 5 per cent. at the Roseland Quarries.

The ratio of rutile to ilmenite in the rutile-bearing nelsonites is variable; and the percentage of rutile ranges from about 5½ in the ilmenite nelsonite to about 64½ in the rutile nelsonite. The nelsonite rutile is uniformly darker in colour than the syenite rutile.

In the Hanover-Goochland area the rutile occurs (1) as loose grains and masses at the surface and in the surface soil, and (2) as a constituent of the underlying pegmatite dykes. The rutile fragments are of variable size, from

small grains up to large masses, one of which weighed between 200 and 300 lb.

The Quebec occurrence referred to is situated about 2 miles west of the village of St. Urbain, which is about 10 miles north of Bay St. Paul on River Gouffre, and about 60 miles east of Quebec. The deposit here is a mixture of rutile and ilmenite occurring in anorthosite, an igneous rock rich in felspar. A sample fairly rich in rutile was calculated to contain about 20 per cent. of rutile and 73 per cent. of ilmenite and hæmatite. The Quebec occurrence has not been worked since 1910, when it was exploited for some time by the General Electric Company, New York.

The rutile of Kragerö, on the south-east coast of Norway, occurs in a dyke of aplite, a white, even-grained rock consisting largely of felspar with some rutile and quartz. The total percentage of felspar in the rock is 64, of which over 52 per cent. is albite (soda felspar). A little ilmenite is associated with the rutile. The rutile is deep reddish-brown in colour, and a sample of it separated as far as possible from the matrix had the following percentage composition: Titanium dioxide, 97·68; silica, 1·06; ferrous oxide, 0·81; chromic oxide, 0·39; vanadic oxide, 0·55. An analysis of the rock showed 25 per cent. of titanium dioxide.

For an account of the South Australian deposits, and of the utilisation of titanium ores, see this BULLETIN (1911, **9**, 136).

NOTICES OF RECENT LITERATURE

A HISTORY OF THE GOLD COAST AND ASHANTI. By W. Walton Claridge. Introduction by Sir Hugh Clifford, K.C.M.G. 2 Vols. Pp. 44 + 1287, Med. 8vo. (London: John Murray, 1915.) Price 36*s.* net; post free United Kingdom 36*s.* 8*d.*

Dr. Walton Claridge is Senior Medical Officer, West African Medical Staff, Gold Coast. His two exhaustive volumes are introduced to the public by the present Governor of the Gold Coast, and the Gold Coast Government, while not assuming any responsibility for the author's statements and opinions, has, with commendable enterprise, contributed to the cost of publication. The volumes may presumably, therefore, in matters of fact be regarded as, to all intents and purposes, authoritative.

As regards Dr. Claridge's opinions, the reader must form his own judgment. Sir Hugh Clifford at least does not pretend that these opinions are always and absolutely unbiassed. He suggests that "as in the case of most Englishmen who have come into contact with the Ashantis, the admiration excited by the many manly and chivalrous

characteristics of this warlike people has engendered in him (Dr. Claridge) so strong an affection for them" that his judgments as to particular incidents in our relations with them may not be wholly dispassionate. Dr. Claridge does not hesitate on occasion to criticise, and the policy of more than one of the Gold Coast Governors is the subject of some frank writing.

This is a first-rate history. It is clear, it does not miss essentials, and it does not elaborate what is non-essential. It should be pointed out that Dr. Claridge's record ceases at the beginning of the present century, and is inevitably very largely a record of war. The prosperous commercial development of the Gold Coast and the Ashantis under the peace conditions since prevailing offer a field to the economic historian which would provide a most useful supplementary volume.

There are several maps and a good bibliography and index. Sir Hugh Clifford's introduction (which occupies several pages) is, in effect, a shrewd essay on the ethics and practice of tropical Empire. Incidentally, the present Governor of the Gold Coast takes a more optimistic view of the health and climatic conditions of the colony than does the Senior Medical Officer.

Stanford's Compendium of Geography and Travel (New Issue). North America: Vol. I. Canada and Newfoundland. Edited by Henry M. Ami, M.A., D.Sc., etc. Second Edition, Revised. Pp. xxviii + 1069, Crown 8vo. (London: Edward Stanford, Ltd., 1915.) Price 15*s.* net; post free, United Kingdom 15*s.* 7*d.*, abroad 16*s.* 2*d.*

Authoritative handbooks on British North America are sufficiently few to make it highly desirable that those available should be kept as far as possible abreast of the rapid developments in the countries concerned. The appearance of this volume, therefore, is particularly welcome, since it brings up to date Dr. S. E. Dawson's well-known first edition, which has long been recognised as a standard work of reference.

The task of the present editor may have been laborious, but no difficulties resulting from lack of material can have been experienced. During the eighteen years that have elapsed since the appearance of the first edition many important and far-reaching changes have taken place in both Canada and Newfoundland, even apart from the remarkable agricultural and industrial development which has been characteristic of the period in question. Among geographical changes may be mentioned the organisation of the present eleven Provinces and Territories of the Dominion; the erection of Alberta and Saskatchewan into Provinces in 1905; and the extension of the areas of Quebec, Ontario, and Manitoba in 1912; while, of political

events, the Canada-Alaska award of London in 1903, defining the boundaries of the Yukon Territory and British Columbia, and the settlement of the "French Shore" controversy in Newfoundland in 1904, are of first-class importance. The extension of the railway system of Canada during the same period may be taken as an index of the remarkable development of the country: whereas, in 1904, there were 19,431 miles in operation, the mileage in the present year is upwards of 43,000 miles, the railways carrying a total annual freight of over 23,000 million tons.

With such developments to record, it has been found necessary to increase the first edition by 350 pages, and to add many new maps and illustrations, the latter now numbering 161. In its new form the book constitutes probably the most useful survey of modern British North America, and should prove invaluable to students, economists, and travellers. The general plan of the book calls for no detailed description: the first three chapters may be regarded as introductory, and in the succeeding sections the Provinces and Territories are dealt with in turn. Dr. Dawson's account of the geographical features of the country has been entirely re-written, and new chapters have been added to deal with the provincial re-organisation referred to above. As the title would imply, the book is essentially a compilation, but by no means the least valuable feature is the full bibliography which is appended. Occasional faults in arrangement are met with; *e.g.* in the chapter on Newfoundland, while passing reference is made to the pulp and paper industry under "Forests," no mention is made of this important development in the section dealing with the "Industries" of the island. Further, a more detailed index would have been an advantage. The maps are excellent, but, judged by modern standards, the illustrations call for no specially favourable reference.

Java: Past and Present. By Donald Maclaine Campbell. 2 Vols. Pp. xiii + 1236. (London: Heinemann, 1915.) Price 36*s.*; post free United Kingdom 36*s.* 8*d.*

Mr. Campbell lived in Java for twenty-three years. He was engaged in business there, was a British Vice-Consul, and a well-known figure in the commercial life of the island, so that these two large volumes are in no sense the usual superficial production of the globe-trotter. Nor does Mr. Campbell, as he expressly points out, lay claim to any particular originality, literary ability, or high standard for his work. He offers it frankly as "a collection of notes, pamphlets, and memoranda, originally transcribed to paper to give myself a more succinct and more intelligent understanding of the history of Java," and he has drawn freely and admittedly on the existing literature on the subject in the interests of "my countrymen in Java and Sumatra,

who desire some record of what the English have done in these islands."

Under these circumstances criticism is largely disarmed, but it may be said generally that from the point of view of the reader not resident in Java the book would have been more valuable had it dealt less with the past (for this part of it is merely a reprint or summary of what others have already said) and more with the present. Mr. Campbell left material for a third volume, a commercial section, and in the interests of readers at home it is to be hoped this section may be published, for it is just here that the author should be able to speak with knowledge and authority.

As it stands the book is extremely discursive and by no means well arranged. But when it leaves past history and comes to actualities, where the author's own knowledge and observation are drawn upon, it is not without value. There are, for instance, chapters on the flora and fauna of the island and on the minerals. A long chapter is devoted to agricultural industries (its proper place would surely have been in the proposed third or commercial volume)—sugar, coffee, kapok, tea, cinchona, rubber, rice, and cocoa. As to the last of these, Mr. Campbell states that "its cultivation in Java has never fulfilled the great expectations which were once formed about it."

Mr. Campbell maintains that the climate of Java, far from being unhealthy, is, save along the marshes of the northern coast, actually healthy, and it is only on this northern coast that the heat is oppressive. The long nights, about twelve hours all the year round, play a great part in cooling the air. For the scenic beauty of the country he finds language hardly adequate.

Despite its serious lack of arrangement and method, the book is by no means uninteresting, and it does undoubtedly help one to a general idea of what Java and the Javan people are like. But if Mr. Campbell had not been so allusive and had given more of the definite results of his own observations and experience, and if, above all, the book had been adequately edited and rigorously "cut" before publication, much would have been gained.

There are a large number of admirable photographs, a distinctly thin index, and a coloured geological and volcano chart of Java and Madoera.

CITRUS FRUITS: AN ACCOUNT OF THE CITRUS FRUIT INDUSTRY, WITH SPECIAL REFERENCE TO CALIFORNIA REQUIREMENTS AND PRACTICES AND SIMILAR CONDITIONS. By J. Eliot Coit, M.S.A., Ph.D. Illustrated. Pp. xx + 520, Crown 8vo. (New York: The Macmillan Company, 1915.) Price 8*s.* 6*d.* net; post free, United Kingdom 8*s.* 11*d.*, abroad 9*s.* 4*d.*

Although, as indicated by the title of this book, the citrus-growing industry is discussed with special reference

to conditions in California, the greater part of the volume will be found of interest and value to planters in any part of the world. The botany and habits of growth of citrus plants are dealt with, the citrus nursery is described, and the improvement of citrus fruits by breeding is discussed. Selection of the site and its preparation, planting the orchard, cultivation, manuring, cover-crops, irrigation, and pruning form the subjects of several well-illustrated chapters. Other chapters deal fully with blemishes of the fruit and their prevention, and also with by-products, diseases and insect pests and their control. A comprehensive bibliography is a feature worthy of mention, revealing the fact that the literature of the subject is widely scattered through numerous periodicals and reports, which are not readily available to most planters. The present volume, in its attempt to bring together in orderly arrangement the information most necessary to the citrus planter, is therefore all the more welcome.

There are many planters in British Territories interested in citrus culture, and the volume should be read by those who wish for practical and up-to-date information and advice on all phases of the subject.

POTTER'S CYCLOPÆDIA OF BOTANICAL DRUGS AND PREPARATIONS. 2nd Ed. By R. C. Wren, F.L.S., with additions by E. M. Holmes, F.L.S. Pp. xl + 339, Crown 8vo. (London: Potter & Clarke, Ltd.). Price 3*s.* 6*d.*; post free, United Kingdom 3*s.* 11*d.*, abroad 4*s.*

This work is a catalogue of vegetable drugs or herbal remedies arranged in alphabetical order under their common or popular names. In each case, the systematic name and natural order of the plant are given together with a list of synonyms. The therapeutical action of each drug is mentioned, reference is made to the ailments for which it is prescribed, and the various preparations and doses are recorded. A special feature of this edition is the description of the distinctive characteristics of each drug by Mr. E. M. Holmes, which will enable the genuine product to be recognised and adulteration detected. It is stated in the preface that an endeavour has been made to mention only such drugs as are of commercial value and may be regarded as obtainable, but in spite of this nearly 700 drugs are dealt with. The book forms a useful work of reference and will doubtless be of considerable service, especially to druggists and herbalists.

SOILS: THEIR PROPERTIES AND MANAGEMENT. By T. Lyttleton Lyon, Ph.D., Elmer O. Fippin, B.S.A., and Harry O. Buckman, Ph.D. Pp. xxi + 764, Crown 8vo. (New York: The Macmillan Company, 1915.) Price 8*s.* net; post free, United Kingdom 8*s.* 6*d.*, abroad 8*s.* 10*d.*

During the last few years a vast amount of information

has been published on certain aspects of soil study, and a text-book, such as that under consideration, which gathers together and clearly summarises the scattered literature, has been much needed by students of agricultural science. The authors, who are on the professorial staff of Cornell University, deal with every branch of soil study from the formation of soils to tillage and dry farming. As indicating the wide scope of the work, mention may be made of some of the subjects considered. The different types of soil are classified according to their geological origin; the texture of the soil and its physical and chemical properties are dealt with; other subjects discussed are the organic matter present in the soil, including an account of Schreiner's work on toxic substances, colloidal matter of soils, soil water and its relation to plants, heat, availability of plant nutrients, absorptive properties of soils, alkali salts, organisms in the soil, the nitrogen cycle, including a summary of the recent work on the relation between protozoa (which, curiously enough, are not referred to in the section on soil organisms) and soil fertility, soil gases, chemical, farm-yard and green manures, and drainage. The book concludes with a useful chapter on soil surveys, a branch of work which has been brought to a high state of perfection in the United States, but which is sadly neglected in this country.

The numerous references to original papers and other publications, which are conveniently given as footnotes, add to the value of the book.

The Rare Earth Industry, including the Manufacture of Incandescent Mantles, Pyrophoric Alloys, and Electrical Glow Lamps. By Sydney J. Johnstone, B.Sc. (Lond.); with a Chapter on the Industry of Radioactive Substances, by Alexander S. Russell, M.A., D.Sc. Pp. xii + 136, Roy. 8vo. (London: Crosby Lockwood & Son, 1915.) Price *7s. 6d.* net; post free, United Kingdom *7s. 11d.*, abroad *8s.*

The rapid increase which has recently taken place in the utilisation of the rare earths in modern industries, such as the manufacture of filaments for electric lamps and of mantles for incandescent gas lighting, has rendered necessary the compilation of text-books on the subject to enable the manufacturer to understand the properties of the materials with which he works and the best methods of employing them for specific purposes. The present volume is specially adapted to meet these requirements; it deals particularly with the applications of the rare earths and contains only such an amount of pure chemistry as is essential for an intelligent apprehension of the subject.

The book consists of nine chapters. The first gives an account of the thorium and cerium industry and includes

information with reference to the manufacture of mantles for incandescent gas lighting and of pyrophoric alloys which form the sparking material of most of the automatic lighters now on the market. Subsequent chapters deal respectively with titanium, zirconium, tantalum and niobium, and tungsten. The sixth chapter is devoted to the incandescent electric lamp industry, and the seventh and eighth to uranium and vanadium. The last chapter, which is concerned with the radioactive elements and their utilisation, gives a concise but clear account of a somewhat abstruse subject. At the head of each chapter is a list of references to the more important papers published on the subject with which it deals. Another useful feature is the reference to patents covering various manufacturing processes and plant.

The work is well illustrated and is furnished with author and subject indexes.

BLACK AND WHITE IN THE SOUTHERN STATES. By Maurice S. Evans, C.M.G. Pp. xii+299. (London: Longmans, Green & Co., 1915.) Price 7*s.* 6*d.*; post free, United Kingdom 7*s.* 11*d.*, abroad 8*s.* 1*d.*

Mr. Evans is the author of the well-known *Black and White in South-East Africa*, and a resident in Natal. He thus approaches the tangled colour question of the southern part of the United States with some advantage over those authors whose observation of the results of black and white coming together is confined to one Continent. As he points out, "the Union of South Africa is the country in which the problem is most nearly like what it is in the Southern States."

Mr. Evans before visiting the Southern States read up the literature on the subject, and, in New York, had the opportunity of discussing the racial question with more than one authority. In the Southern States he travelled widely, in districts remote as well as near. He talked to every one he met, and he stayed at the homes of both black and white.

His deliberate conclusion is that in agriculture, on the land, is the golden opportunity, but at the same time the last opportunity of the coloured people in the United States. He considers it perfectly possible for the average coloured agricultural labourer—if he cares to do so—to save enough from his wages to enable him in no long period to become the cultivator of his own land. A self-contained coloured community might thus be formed.

The position of the people of colour in the towns Mr. Evans regards as beyond remedy, and he notes a decided hardening of recent years in the feeling of the Southern white man against the negro.

This is a thoughtful and thoroughly impartial book.

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LE MAROC. Par Augustin Bernard. 3me éd. Pp. viii + 420, Demy 8vo. (Paris : Félix Alcan, 1915.) Price 5 francs; post free, United Kingdom 4*s.* 5*d.*, abroad 4*s.* 6*d.*

PICTURESQUE PARAGUAY. By Alexander K. Macdonald. Pp. 498, Foolscap 4to. (London: Charles H. Kelly.) Price 16*s.*; post free, United Kingdom 16*s.* 5*d.*, abroad 16*s.* 7*d.*

THE RUBBER INDUSTRY OF THE AMAZON, AND HOW ITS SUPREMACY CAN BE MAINTAINED. By J. F. Woodroffe, edited and with additions by H. H. Smith, with a Foreword on the Latin-American Indian by Viscount Bryce, O.M., P.C. Pp. xlviii + 435, Demy 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1915.) Price 21*s.* net; post free, United Kingdom 21*s.* 6*d.*, abroad 21*s.* 9*d.*

CORK: ITS ORIGIN AND INDUSTRIAL USES. By G. E. Stecher. Pp. v + 83, Demy 8vo. (London: Constable & Co., Ltd.) Price 4*s.* 6*d.* net; post free, United Kingdom and abroad, 4*s.* 8*d.*

MARKET GARDENING. By F. L. Yeaw. Pp. vi + 102, Crown 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1915.) Price 3*s.* 6*d.* net; post free, United Kingdom and abroad, 3*s.* 8*d.*

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RURAL SANITATION IN THE TROPICS. By Malcolm Watson, M.D., C.M., D.P.H. Pp. xvi + 320, Demy 8vo. (London: John Murray, 1915.) Price 12*s.* net; post free, United Kingdom 12*s.* 5*d.*, abroad 12*s.* 7*d.*

LIMES AND CEMENTS. By E. A. Dancaster, B.Sc. Pp. xii + 212, Crown 8vo. (London: Crosby Lockwood & Son, 1916.) Price 5*s.* net; post free, United Kingdom and abroad, 5*s.* 5*d.*

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Printed by Hazell, Watson & Viney, Ld., London and Aylesbury, England.